(2) Recreation Equipment. The major share of expenditures for recreation goes into the purchase of recreation equipment. For estuarine-type recreation the principal types of equipment include:

Boats, motors, and trailers
Water skis
Fishing gear
Hunting gear
Clothing (including swim suits).

Recreation-equipment expenditures represent the greatest contribution of the recreation industry to the gross national product. Purchases of equipment, however, are widely distributed and are not necessarily confined to the regions of estuarine recreation.

(3) Recreation-Site Goods and Services. In addition to expensive recreation equipment, most estuarine recreation outings require some expenditure on local recreational goods and services. For example:

Gasoline
Fishing tackle and bait
Guides
Boat rental
Suntan lotion, etc.
Souvenirs.

Expenditures on such goods and services are small compared to expenditures on major items of recreation equipment. However, the impact of these expenditures is strictly local and may tend to make a more significant contribution to a local economy than direct charges on equipment purchases. In particular, the incomes of many recreation operators, private and public, may be enhanced considerably by providing these types of services and goods.

(4) Nonrecreation Goods and Services in Recreation Areas. Any extensive visit to a recreation site (even a few hours in some cases) requires expenditures for goods and services which would otherwise be obtained at home or at another recreation area including:

Food
Lodging
Personal service (laundry, beauty shop, etc.)
Car maintenance.

Much of the benefit of having a local recreation industry accrues to a region through its ability to provide such goods and services. Local jobs are created for the purpose of serving customers who primarily bring outside sources of funds into the region. In this sense, goods and services for a local tourist or recreation trade substitute for basic industries (exporters of products) in regions with economies weak in basic industry. Therefore, most regional analyses of recreation resources and tourist attractiveness stress the necessity of developing facilities and services for visitors to the area.

(5) Transportation. Transportation costs occur in almost every individual participation experience in outdoor recreation. Some of these costs consist of:

Car expense

Tolls

Public transportation

Parking.

Transportation expenditures are similar to equipment purchases in that they have wide geographic distribution. The bulk of such expenditures occur near an individual's home; a second share taking place near a recreation site, with the remainder distributed between these two locations.

Transportation costs are useful in some circumstances for distinguishing the attractiveness of one recreation site in comparison to a second. Given the same type of activities, the site which attracts users from greater distances (and therefore at higher cost) is the one which has the greater utility to users.

Sport Fishing

Saltwater sport fishing is far more closely related to estuaries than commercial fisheries.* Land based fishing from piers, bridges or the surf involves only those species whose habitat is estuarine or in shallow coastal waters. Marine based fishing, via charter or individually owned craft, depends upon estuaries for safe mooring and launching. Finally, a majority of the species sought in all sport fisheries depend upon the estuaries for some phase of their life cycles.** And, primarily because of the access and harbor factors, much of the land-based economic impact of saltwater sport fishing occurs in areas located on estuarine waters.

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*Mock, C, Importance of Gulf Estuaries and Problems Facing Our Fishery Resources Proc. 11th International Game Fish Conference (1967), pp 66-68.

**See Appendix B for a description of the biological estuarine dependencies characteristic of salt water fisheries.

Data. The primary series of data available was assembled for the Department of the Interior by the Department of Commerce, Bureau of the Census, in the National Survey of Fishing and Hunting. Statistics on sport fishing differentiate between freshwater and saltwater but not between estuarine and deep sea. The survey used 357 areas throughout the 50 states reaching approximately 16,000 households or 45,000 individuals. Respondents who participated in fishing and hunting, a total of approximately 6400 persons, were later interviewed. From these samples come virtually all of the data on sport fishing and hunting in the United States. While by far the best data source in the field, the statistics deduced from this survey are used repeatedly in and out of context in almost all studies and projections involving these forms of recreation. Of particular consequence is the use of figures for average values of fishermen and hunters expenditures, which are quite variable by geographic location and by specific activity.

There are many regional studies of estuarine sport fishing using local surveys of species, catches, and other biological factors significant in sport fishing. Regional analyses, which also include economic factors, are the only means of establishing a true evaluation of the impact of sport-fishery resources. Examples of regional studies that include the economic impact of sport fishing on estuarine areas would be the series of investigations completed by the Massachusetts Division of Marine Fisheries on selected estuaries throughout Massachusetts.* More often, data which are claimed to represent the economic impact of sport fishing on a region are merely interpretations and extrapolations of average national expenditure figures used out of context in regional applications.**

National data for expenditures by saltwater fishermen are presented in Table A-8 for the years 1955, 1960, and 1965, to indicate the economic trend over a decade. These expenditures do not represent a total contribution to the economy since they do not express the effect of multipliers. Furthermore, gross expenditures may be a conservative indicator of the value that users placed upon the activity. As Crutchfield has explained, "Where people choose freely to spend money on this activity we can legimately infer that they value it at least as highly as other things that could have been puchased for the same amount".***

Crutchfield also points out that the gross expenditures for estuarine related sport fishing should not be mistaken for net expenditures since the costs of the local, state, and Federal services are not included. Some of these services, such as Coast Guard and weather forecasting services, pollution control, research activities and overall fish and wildlife management, are diffused throughout the economy. Another omission from this economic indicator is the full resource cost for the right to fish at a given estuary; i.e., the rent of the resource.

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*For instance, Jerome, Chesmore, Anderson and Grice, A Study of the Marine Resources of the Merrimack River Estuary, Department of Natural Resources, Monograph #1 (June, 1965).

**See Sport Fishing Institute Bulletins #172 and #81.

***James A. Crutchfield, "Valuation of Fishery Resources", Land Economics, Vol. XXXVIII, No. 2 (May, 1962), pp 145-154.

TABLE A-8. EXPENDITURES OF SALTWATER FISHERMEN

	Year					
	1955*		1960		1965	
	Total Spent, $1,000	Avg per Fisherman, $	Total Spent, $1,000	Avg per Fisherman, $	Total Spent, $1,000	Avg per Fisherman, $
Food and lodging						
Food	25,238	5.54	56,705	9.01	83,952	10.11
Lodging	18,261	4.00	12,749	2.03	24,503	2.95
Transportation						
Automobile	42,828	9.40	68,293	10.85	72,933	8.78
Bus, rail, air, and water			5,037	.80	12,388	1.49
Auxiliary equipment						
Boats and boat motors	--	--	175,077	27.83	237,216	28.56
General	--	--	19,701	3.31	22,410	2.70
Fishing equipment	54,458	11.95	73,945	11.75	73,098	8.80
Licenses, tags, and permits	1,449	.32	3,575	.57	4,368	.53
Privilege fees and other						
Annual lease and privilege fees	--	--	4,595	.73	6,166	.74
Daily entrance fees	--	--	3,379	.54	7,831	.94
Bait, guides, and other trip expenses	--	--	182,127	28.95	236,958	28.53
Boat launching	--	--	6,555	1.04	7,330	.88
Other	346,705	76.08	14,457	2.30	10,503	1.26
Total	488,939	107.29	626,191	99.52	799,656	96.29

Source: National Surveys of Fishing and Hunting, 1955, 1960, and 1965.

*1955 Survey not comparable in all details to succeeding surveys.

Estuarine Boating

There are no accurate data expressing the total number of boats used on estuaries or even on coastal waters in general. However, a study of activities on the U.S. continental shelf makes the estimate that "1,285,000 boats (34 percent of the total of... numbered boats in the U.S.) are used in shelf environs. This seems to indicate that a 25 percent figure for boating expenditure in (continental) shelf regions is not too high."*

Data show that, on a per capita basis, coastal states have fewer recreational boats than inland states, a fact seemingly supporting the estimate that only 25 percent of pleasure boats are used in coastal waters. In 1966, coastal states with 120 million people, or 61.5 percent of the total population accounted for 55.4 percent of total sales of outboard motors. Expressed differently, there are over 20 percent more boats per capita in inland states than in coastal states.

Several coastal states with high populations and high buying power but with low per-capita sales in recreation boats, include: California, Connecticut, Maryland, Massachusetts, New Jersey, and New York.

Each of these states has large estuarine water areas adjacent to large masses of people, yet are considered "weak markets" in the boating industry. Coastal states considered "strong markets" are those with relatively low buying power but high sales of boats, include: Alabama, Florida, Louisiana, Maine, New Hampshire, South Carolina, and Washington.

Overall, the strongest recreation boating region in the nation is the East North Central, particularly Wisconsin, Minnesota and Michigan. These states have boat registrations of 3.1, 2.8, and 2.3 times the national average, respectively.

For 1966 in the U.S. an estimated $3 billion was spent at the retail level on boating recreation-related expenditures. Items included:

(1) Equipment

(2) Services

(3) Insurance

(4) Fuel

(5) Mooring and launching fees

(6) Boat club membership.

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*U.S. Department of Commerce, ESSA= Development Potential of U.S. Continental Shelves, Washington (1966).

Sales reports from many individual product categories indicated increases in dollar sales from 1965-1966 although generally they were small increases. Some areas showed losses in unit sales while indicating gains in dollar sales. The outboard-boat market, for example, sustained a slight loss in unit volume in 1967, although there was a small increase in total dollars due to an average boost of $21 per unit over 1966 for each boat sold. Most products enjoyed peak sales in 1959 and suffered a severe drop in the following years. From 1964 there has been a gradual upward growth pattern, although the 1959 peak has not yet been regained. Exceptions to this trend have been the life saving equipment market, which has been on a decline, and the water ski market, which has been flourishing.

The following tabulation illustrates equipment sales for 1966:*

Item	Unit
Outboard boats	260,000
Inboard boats	36,000
Sailboats	13,000
Boat trailers	160,000
Outboard motors	444,000
Inboard engines	92,000
Inboard/outdrives	46,000
Fuel	1,000,100 gallons
Marine electronics gear	$17,500,000
Safety	$10,000,000
Waterskiis	810,000

Pleasure Boating-Related Activities.** In 1967 the following boating-related sports were pursued:

Sport	Number of People, Total U.S.
Pleasure boating	41,375,000
Water skiing	9,500,000
Fishing	30,000,000
Skin and scuba diving	3,000,000

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*The Boating Business 1967, The Boating Industry.

**Source: "The Boating Business-1967", The Boating Industry.

In the course of these activities the estimated number of pleasure craft and attendant accessories was broken down as follows:

Pleasure boats	8,275,000*
Outboard boats	4,843,000
Inboard boats	591,000
Sailboats	561,000
Houseboats	5,500
Pontoon boats	22,500
Canoes	265,000
Inboard/outdrive	112,000
Miscellaneous draft	2,280,000
Outboard motors	6,904,000
Inboard engines	671,500
Inboard/outdrive units	125,000
Boat trailers	3,560,000

Impact of Marinas. As with most water-based recreation activities, boating is heavily dependent upon related land-based facilities. Both freshwater and saltwater boating require the following land-based services:

(1) Sales outlets
(2) Major servicing
(3) Maintenance
(4) Fuel
(5) Access or mooring
(6) Storage
(7) Transportation
(8) Lodging
(9) Food
(10) Recreation
(11) Weather notification.

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*Assume estuarine use comprises an estimated 25 percent of all data.

"Marinas" represents the broad term designating land-based service establishments for recreational boating. Smaller boats along coastal waters can be launched at beaches or ramps, but many coastal boats require some sort of launching or berthing facilities provided by marinas. Many municipalities have developed public marina facilities, generally on a less-luxurious scale than private facilities.

Large inland marinas, comparable to those located in coastal waters, are developed along the Great Lakes and the major inland waterways. However, the type of boating activity along the coasts tends towards larger and more expensive land-based facilities than those for inland waters. Investigation of marinas and the kinds of services which they provide can indicate the relationship between an estuarine-recreation activity and the land-based economy.

Access and Launching. The prime requisite for boating is access and launching, including roads and land development. Launching must include ramps, winches, and other services. Size and complexity of launching facilities increase with boat size, which in turn tends to increase with waterway size.

Slips and Moorings. In a nationwide study of 417 marinas by the National Association of Engine and Boat Manufacturers, it was reported that the lack of slips and moorings was the largest single factor retarding the sale of new boats and motors.* From the 417 marinas:

(1) there was a total of 35,592 slips

(2) of these slips 94 percent were occupied

(3) 279 marinas turned people away

(4) 233 had waiting lists

(5) 397 said more boats could be sold

(6) of all marinas, 77 percent were 100 percent occupied.

Estimated Revenues. Table A-9 shows the estimated revenues of a 200-slip marina.

In addition, boaters spent an average of $54,000 in the communities nearby the marinas. Survey findings revealed that during a 5-month season, boatmen spent an average of $9 per day. The boatowner was able to boat an average of 30 days per year (estimates for Southern states are higher).

Tables A-10 and A-11 indicate the range of expenditures and the number of boating days per year:

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*Knight, H. B., The Marina and the Community, Boating Facilities, Outboard Boating Club of America, Vol 6 (Feb. 1964).

TABLE A-9. ESTIMATED GROSS REVENUES, 200-SLIP MARINA

Slip and mooring rentals	$ 35,000
Sale of accessories and equipment	23,500
Repairs	21,000
Sale of new boats and engines	19,000
Sale of fuel and oil	18,500
Winter storage charges	18,000
Sale of used boats and engines	15,000
Restaurant and bar sales	8,000
Boat rentals	7,500
Sale of bait, tackle, etc.	6,500
Sleeping quarters	4,000
Sale of groceries and ice	4,000
Total	$180,000

Source: Knight, The Marina and the Community, p 5.

TABLE A-10. DAILY EXPENDITURES FOR ALL PURPOSES BY LAND-BASED BOATERS

Amount	Percent of Survey Spending
$ 0 to $ 5	26.2
$ 6 to $10	40.5
$11 to $15	23.8
Over $15	9.5

Source: Knight, The Marina and The Community, p 5.

TABLE A-11. NUMBER OF BOATING DAYS PER YEAR

Number of Days	Percent of Boaters Boating
20 to 30	47.5
31 to 50	30.0
Over 50	22.5

Source: Knight, The Marina and The Community, p 5.

Size of Marinas. Table A-12 indicates the range in size of the marinas in this country.

TABLE A-12. ESTIMATED NUMBER AND AVERAGE SIZE OF U.S. MARINAS

Number of Berths	Estimated Number of Marinas	Percent of Total
Under 50	2250	50
50 to 99	1125	25
100 to 199	675	15
200 to 299	225	5
300 to 399	135	3
400 and Over	90	2
TOTALS	4500	100

Source: Jones, Charles, Where Marina Profits Come From, Boating Facilities, Outboard Boating Club of America, Vol 7 (1965).

Services of Marinas. Table A-13 describes the services offered by marinas.

TABLE A-13. MAJOR SALES AND SERVICE FACILITIES OFFERED BY U.S. MARINAS

	Number of Marinas Offering	Percent of Marinas Offering
Repairs and service	2700	60
Hauling and launching	3465	77
Fuels	3330	74
Storage; seasonal or winter	3150	70
Berths or slips	4500	100
Sales - boat, engine, trailer (new and used)	2250	50
Sales - marine hardware Accessories and boating supplies	2250	50
Sales - fishing supplies, ice, bait, tackle, etc.	3015	67
Boats for hire Rowboats, charter, etc.	2070	46
Beverages (soft drinks)	3150	70
Rest rooms	3465	77
Snack bars	1350	30
Restaurants	945	21
Groceries	225	5

Source: Jones, Where Marina Profits Come From, p 9.

These services provide an income for operators as described in Table A-14.

A unique advantage of a marina is that even in cold weather it can continue to offer some services and thus alleviate the problem of seasonality which afflicts employment in the recreation industry. Boat storage and maintenance are perennial requirements. Boat sales, to a lesser extent, are also carried out throughout the year. Marine facilities can be utilized for winter sports and social activities and restuarants can remain open throughout the year.

TABLE A-14. AVERAGE MARINA INCOME SOURCES

Facility	Profit Ratio[a]	Percent of Gross Income
Slip rentals	39.2	19.4
Winter storage	27.4	10.0
Repairs, overhauling	26.7	11.7
Sales:		
New boats, motors	16.4	10.5
Used boats, motors	8.8	8.2
Marine supplies	22.8	13.1
Petroleum products	15.1	10.1
Boat rentals	15.2	4.2
Restaurants and bar		4.4
Groceries, ice coin venders		2.1
Bait, tackle		3.7
Boatel units	14.9	2.6

Source: Jones, Where Marina Profits Come From, p 9.

(a) Average percentage of net profit after deducting specific costs incurred by each facility.

Swimming

As indicated in an earlier section, there are few tangible data on the participation in estuarine swimming. Most data available are made on the basis of "educated guesses", a practice which has to be adopted in this case to provide even an "order-of-magnitude" estimate of expenditures associated with estuarine swimming.

The report on Development Potential of U.S. Continental Shelves* cites expenditures for coastal swimming of all types at about $1.5 billion per year. However, 60 percent of this total, or $900 million, is attributed to vacation expenditures for visitors to Florida. Utilizing data compiled by the 1966 Florida Tourist Study**, less than 20 percent of the visitor expectation was for beaches and swimming. Furthermore, many of the other activities which respondees participated in require greater levels of expenditure than swimming, such as fishing and hunting, commercial attractions, boating, dancing, and night life Considering the data from the Florida Tourist Study, the value of $900 million appears to be unreasonably high to be attributable only to swimming. Nevertheless, assuming that $1.5 billion is expended annually for coastal swimming, 10 percent or $150 million may be related to estuarine swimming activity. These expenditures have been broken down thusly:*

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*Op. cit.

**Florida Development Commission, 1966.

Purchases of swimsuits and equipment	11 percent
Local transportation	4 percent
Fees, food, and miscellaneous	9 percent
Florida vacations	61 percent
Other vacations	15 percent
$150 million	100 percent

Hunting and Wildlife Management

The only data available on expenditures by hunters were provided by the National Survey of Fishing and Hunting. However, there are no means by which to ascribe the data in terms of estuarine-related hunting activities. Total hunter expenditures in 1965 were $1.1 billion, with the following breakdown given by type of game.

Type	Expenditures
Big game	$ 418,764,000
Small game	615,234,000
Waterfowl	87,136,000
Total	$1,121,134,000

It may be assumed that big game are almost totally nonestuary dependent, while small game are largely nonestuary dependent. On the other hand, the life cycle of some species of waterfowl is dependent, at least in part, upon estuaries and adjacent marsh and land areas. Furthermore, much of the actual hunting activity takes place along the coastal flyways. Therefore, some of the $87 million of hunter expenditures would be related, at least indirectly, to estuarine hunting and waterfowl management.

In addition to hunting activities, there are numerous wildlife preserves along estuarine waters. Maintenance of these areas requires governmental expenditures for the purposes of wildlife management and preservation. Some of these expenses are directly applicable to those game which are essential to the hunting sport, while others are more broadly related to the overall program for conservation and wildlife preservation.

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*Continental Shelf Report, op. cit.

ECONOMIC VALUES OF ESTUARINE RECREATION AS MEASURED BY REGIONAL IMPACTS

The economic impact of an industry upon a region, such as that adjacent to an estuary, is generally measured by several economic indicators. Impact is a term used to describe a region's response to its income sector, employment, supporting industries and services, and growth potential. Impact, therefore, is more than just the dollar volume of business which one industry contributes to an economy; it is the effect on all sectors of that economy due to the presence of a particular economic activity, in this case estuarine recreation.

Regional Analysis - Southern New England

Several coastal and estuarine regions have investigated the impact of coastal and estuarine related activity on their economies. Perhaps the most sophisticated has been a series of studies done at University of Rhode Island on the economic impacts of Narragansett Bay and the Southern New England region, including Rhode Island, Southeastern Connecticut and the Plymouth-Cape Cod sectors of Massachusetts. *

In a 1963 study of the Economic Impact of Narragansett Bay, it was estimated that about 7 percent of the monetary impact of uses of the bay was in activities related to estuarine recreation, namely (1) general summer sales, (2) ship and boat building and (3) boatyards and marinas. On the other hand, over 90 percent of the impact was due to a naval installation, an activity which in trun contributes to the level of recreation use of the bay. Being an early study on the economic impact of marine resources, the author cautions that the monetary estimates used (see Table A-15) are not directly comparable, as in the case of wages for naval personnel compared to sales compared to taxes.

In discussing impact of estuarine activity, the author had some pertinent qualifications regarding the use of monetary data in economic impact studies. These qualifications are equally applicable to the present National Estuary Studies as well.

1. The impact of a dollar expenditure in each of two marine industries may be vastly different. Purchase of a boat manufactured outside of the estuarine region has impact on the local area only in payment of those services required to sell the boat locally. On the other hand, "value added" by a local fisherman or other local beneficiary of estuary use is retained in the community.

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*Including Rorholm, Economic Impact of Narragansett Bay (1963).
Alexander, Narragansett Bay: A Marine Use Profile (1966).
Rorholm, The Economic Impact of Marine Industries in the Southern New England Region (1967).
Rorholm, Lampe, Marshall and Farrell, Economic Impact of Marine-Oriented Industries - A Study of the Southern New England Marine Region (1967).

TABLE A-15. MONETARY IMPACT OF ACTIVITIES RELATED TO NARRAGANSETT BAY

	% of Total
Naval installations	91
General summer sales[a]	4
Ship and boat building[a]	2
Fish landings	1
Boatyards and marinas[a]	Less than 1
Transportation	Less than 1
Real estate taxes	Less than 1
Research	Less than 1
Municipal expenditures	Less than 1
Total: $145,000,000 per annum	100

Source: Rorholm, Economic Impact of Narragansett Bay, p 4.

(a) Recreation oriented activities.

2. Estimates of summer trade from sales-tax data ignore the fact that factors which contribute to the summer activity lessen winter sales, and therefore value added due to summer sales may be an indication of year-round economic weakness rather than a beneficial effect from summer visitors.

A later study on the economic impact of marine industries in the Southern New England Region characterizes the impact of those estuarine activities which are recreation dependent. Marinas and boat yards have four characteristics as recreation enterprises which differentiate them from other recreation types of businesses.

(a) They are more nearly year-round, adding stability to local employment.

(b) Boating brings business to the area, particularly to merchants and restaurants.

(c) Boat owners generally desire to live near their boats, exerting an upwards influence on land values.

(d) Marina and boatyard facilities are generally compatible, and sometimes complementary with residential development.

Beaches and museums contributed a very small portion of the total income to the Southern New England Region, (0. 15 percent) yet are characterized as being good "gateway" enterprises. They are attractions for people in the area, who usually spend additional money on food and lodging. Furthermore, income to beaches and museums remains in local possession. Their impact, however, includes high demands on regional transportation facilities and, for beaches, high demands on police efforts.

Seaside restaurants and hotels catering to recreationists are generally seasonal activities. Though several of the establishments in the Southern New England Region were open all year they reported, on the average, that 68 percent of their business was transacted in the period between Memorial Day and Labor Day. Generally, restaurants and hotels depend upon customers brought there by other attractions. However, it is not unusual to see these units grow into attractions themselves through attention to quality. In this sense they can become important in improving the general recreational environment of an area, and even serve to lengthen the recreational season by attracting meetings and conventions.

The Southern New England Study reported on certain effects of marine industries on the local region. These effects, described subjectively, are listed in Table A-16.

The most recent study at Rhode Island evaluates multipliers indicating the salient components of economic impact of marine industries. Multipliers provide a key to economic impact and development strategies because they are concerned not with the magnitude of an economic sector but with the significance of changes in the sector and their relation to the economy as a whole. The multipliers represent the effect on the economy in dollars, given a dollar change in final demand for an economic sector, provided that the resources are available for the change.

1. General multipliers — represent total effect on the economy.

2. Personal imcome multipliers — represent effect on personal imcome, often a key factor in public policy decision.

3. Nonmarine multipliers — show the rate at which each marine sector stimulates business in the rest of the region's economy.

Table A-17 presents the multipliers showing impact of marine sectors of the economy for the Southern New England Marine Region, 1965. The multipliers shown indicate that recreation industries are about average in their impact on the Southern New England Region relative to other industries. Commercial fisheries represent the greatest local effect of any marine industrial sector.

Based upon their thorough analyses of the Southern New England Region, the authors evaluated the potential of the recreation industries in the region. Water-based recreation is one of the fastest growing recreation activities. The growth appears to occur

TABLE A-16. SELECTED EFFECTS OF MARINE INDUSTRIES

Industry	Gateway Characteristics[a]	Traffic[b]	Pollution[c]
Recreation oriented			
Marinas and yards	3	0	1
Beaches and recreational	4	2	1
Marine restaurants	2	0	0
Nonrecreation oriented			
Marine retail and wholesale	1	0	0
Marine manufacture	2	2	2
Fishing	2	1	1
Research	2	0	0
Marine agents and brokers	0	0	0
Marine construction and transportation	0	0	0
Marine military	5	2	2

Source: Rorholm, Lampe, Marshall and Farrell, Economic Impact of Marine Oriented Industries.

(a) Gateway Characteristics - Stimulation of employment in other business in the area directly as opposed to indirectly through earnings of employees. 0 = not a gateway enterprise, to 5 = strong gateway effect.

(b) Traffic Generators - Degree to which activity puts a burden on local transportation network. 0 = low; to 2 = high.

(c) Pollution Effect - Degree of air, water or space pollution. 0 = low; to 2 = high. (Defined as the general "messing up" of the environment which often accompanies some commercial enterprises.).

TABLE A-17. MULTIPLIERS FOR MARINE ACTIVITIES

Activity	General	Personal Income	Nonmarine
Recreation-oriented			
Marinas and yards	2.76	0.94	0.43
Charter fishing	3.07	1.17	0.47
Partially recreation oriented			
Ship and boat building	1.99	0.71	0.22
Marine wholesale and retail	2.75	0.87	0.42
Construction and towing	1.97	0.64	0.27
Other marine	2.68	0.96	0.50
Nonrecreation oriented			
Fish catching	2.96	1.18	0.46
Fresh-fish processing	3.32	1.07	0.41
Frozen-fish processing	3.74	1.16	0.48
Fish wholesaling and jobbing	3.41	1.09	0.47
Marine manufacturing	2.37	0.95	0.32
Research and education	1.95	0.62	0.28
Marine military	2.73	1.22	0.41

Source: Rorholm, Lampe, Marshall and Farrell, Economic Impact of Marine Oriented Industries.

across the spectrum of water-based recreation, including boating, swimming, fishing, and general use of the marine environment. They estimated recreational growth to be based on an approximate regional economic value of $200 million for marine recreation activities. Seventy-eight percent of this base is derived from summer visitors, and the remaining 22 percent from increases in all other industries due to pleasure boating, fishing, and tourism.

Their conclusion is that there will be increased pressure on the coastal resources of the North Atlantic seaboard, and particularly on the Southern New England Marine

Region with its historic significance and many unique characteristics, as a recreation area. They further conclude that the social and economic impact of such growth will depend on the extent to which private and public organizations are able to protect the quality of the marine environment while advancing its development.

Seasonal Impact of Recreation on Employment

The full impact of the tourist trade on employment trends in resort areas is not reflected in available employment data since much of this employment is not included under state employment bureaus. Four New Jersey counties studied, however, indicate certain definite trends in seasonal employment. (See Table A-18). The counties are chiefly resort areas; the economy is dominated by the tourist business and agriculture. Thus, trade and service industries are particularly prevalent. *

TABLE A-18. UNEMPLOYMENT RATES IN FOUR COASTAL NEW JERSEY COUNTIES, 1967

	Atlantic	Ocean	Monmouth	Cape May
Annual Average	5.7	5.9	4.9	10.2
January	8.8(a)	7.8	6.2	15.4
February	8.3	8.3(a)	6.5(a)	15.6
March	8.0	7.1	6.1	13.8
April	6.7	5.8	5.2	11.9
May	4.7	5.3	4.5	8.8
June	4.1	5.4	4.9	6.9
July	3.9	5.1	4.7	5.9
August	3.1(b)	4.8	4.2	4.9(b)
September	3.7	4.6(b)	3.7	6.5
October	4.9	5.0	3.5(b)	10.5
November	5.8	5.1	4.2	12.8
December	7.6	5.9	4.7	15.9(a)

Source: N. J. Division of Employment Security.
(a) Highest rate for year.
(b) Lowest rate for year.

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*New Jersey Division of Employment Security.

These industries are at their strongest during the summer season, and employment fluctuates according to the demand, i.e., the tourist influx. Job holding expands sharply from March to reach the highest level of employment in August or September. Hiring for the summer recreation season includes workers for the hotels, restaurants, amusements, concessions, and retail-trade businesses. Much of the hiring includes seasonal-job seekers who migrate to the area for the summer season only and compete with the local job seekers.

During 1960 in Atlantic City, 24 percent of the unemployed workers of the area were listed in the service occupation. Forty-seven percent of all unemployed were women, 50 percent of all unemployed were over 45 years of age, 18.5 percent of all unemployed were under 27 years of age. In Atlantic City the Convention season begins in February and continues until mid-April, providing employment for the local service and trade workers in otherwise slack months.

ECONOMIC VALUES OF ESTUARINE RECREATION BY USER BENEFITS

The most critical issue in the evaluation of an estuarine recreation resource, such as a fishery, is the net benefits attributable to an added investment or a change in management policy. The impact of management on a natural water body is difficult to directly measure, though attempts have been made to some man-made reservoirs and other restricted types of recreation sites. While these procedures are recognized as being extremely difficult, one specialist concludes that, at worst, such surveys would yield more useful information than the large sums now spent on "essentially useless studies of fishermen's gross expenditures."*

The following approaches and measures have been used in evaluating recreation benefits:

1. Net benefits from estuarine pollution control
2. Waterfront land-value enhancement
3. Landed value of estuarine sport fish
4. Consumer surplus-demand analyses
5. User-days fixed recreation benefits.

Net Benefits From Estuarine Pollution Control. One study applied the net-value approach to estuarine fishing attempted to measure net recreation benefits from pollution control in Yaguina Bay, Oregon.* Demand equations and "success per unit of effort" were estimated for three estuarine sport fisheries. The methodology was illustrated by means of an assumed reduction in angling success resulting from water pollution. The direct or net recreation benefits were identified as the consumer surplus that would result from the prevention of water pollution. Although just an exploratory effort to measure the direct benefits of estuarine sports fishing, the Stevens research points toward the direction which meaningful economic research must take in the analysis of estuarine recreation. Coupled with estimates of incremental costs of pollution control, research of this nature would yield a basis for comparing investment in estuarine management (i.e., pollution control) with prospective recreational benefits.

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*Crutchfield, op. cit., p. 148.

Waterfront Land-Value Enhancement. Where bodies of water are in demand as recreation resources, the value of adjacent lands tend to increase in response to the demand for recreation. The value increase may be termed as direct benefits to property owners. These benefits represent the land owners' willingness to pay additionally for land which possesses recreation opportunities or visual and environmental ammenities. Land-value increases are much better documented for man-made reservoir sites than for estuarine adjacent land areas.** However, it is generally conceded among land-use planners that waterfront locations where there are recreation opportunities do influence the price of land.

Some measure of the benefits of land-value enhancement was provided by the City of Hampton, Virginia, for a publication on urban waterfront renewal.*** Waterfront lots were valued first as comparable nonwaterfront lots, and then a waterfront-location-value factor was applied.

AAA Class - 100 percent (or double the lot value or square-foot value)

(1) Protected, inland

(2) Readily accessible

  (a) good beach

  (b) less than 100' dockage necessary for boats at low water

  (c) not limited to small boats (no low bridges to open water)

(3) Pleasant view

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*Stevens, Joe B., "Recreation Benefits From Water Pollution Control, Journal of Water Resources Research, Volume 2, No. 2, 1966, p. 167.

**Wisc. Dept. of Resource Development, Waterfront Renewal, Technical Supplement (1964), pp. 141-142.

***Knetsch, Jack L., The Influence of Reservoir Projects on Land Values, Journal of Farm Economics (February 1964), pp. 231-243.

AA^1 Class - 80 percent

- (1) On open water, unprotected
- (2) Readily accessible
  - (a) good beach
  - (b) less than 100' dockage necessary for boats for low water
- (3) Pleasant view

AA^2 Class - 70 percent

- (1) Protected, inland
- (2) Accessible at low tide or high for small boats only
- (3) Pleasant view

A^1 Class - 60 percent

- (1) Protected, inland
- (2) Limited access
  - (a) muddy lowland
  - (b) needs more than 100' dock to reach water at low tide
  - (c) limited to small boats
- (3) Pleasant view

A^2 Class - 50 percent

- (1) On open water, unprotected
- (2) Limited access
  - (a) poor facilities for boats
  - (b) poor or no beach
  - (c) not limited to small boats
- (3) Pleasant view

B Class - 40 percent

(1) Protected, inland

(2) Limited access

  (a) muddy lowland

  (b) no access except at high tide

  (c) limited to small outboard boats

(3) View obstructed or no view of open water or view not classed as pleasant

B Class - 40 percent

(1) On open water

(2) Limited access

  (a) poor facilities for boats

  (b) limited to small boats

(3) View obstructed or otherwise not classed as pleasant

C Class - 20 percent

(1) Protected inlet or canal

(2) Accessible by small boats except at low tide

(3) Narrow passage permitting only small parallel dock

(4) No special view factor.

Landed Value of Estuarine Sport Fish. Economists are quick to point out that the product in sport fishing is recreation, not fish. As a consequence, their interest lies with evaluating the economic impact on fishermen participating in this activity. In many estuaries, however, particularly those where sport fishing and commercial fishing are competitive, the value of the catch by sport fishermen may have real economic consequences. In estuarine waters yielding a limited amount of fish, it may be assumed that each pound of sports catch is of equal landed value by weight to a comparable commercial catch. However, value added to commercial landings through processing represents a multiplier factor of possibly 3. This value added could be reduced if the commercial catch were diminished by sport fishermen depleting fishery stocks. In addition, a greater share of a sports-fish catch becomes wasted.

Although fish landings are a "bonus" to sport fishermen, 15 percent of the respondents to an Arizona survey gave a motive for sport fishing as "economic", indicating the desirability of the catch as an economic supplement.* Furthermore, the economic motive was the most rapidly increasing motive stated in the survey, rising from 5 to 15 percent in the period 1960-1965. Therefore, the economic consequences of sport fishing may not be minimal.

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*Davis, W. C., Values of Hunting and Fishing in Arizona, Arizona Game and Fish Department (1965).

Estimates of sports-fish catch in estuaries compared to commercial catch vary significantly. One of the most thorough studies was the Massachusetts Marine Sports Fishery Inventory of 1961* encompassing the entire marine fishery resources of that state. The inventory estimated that 9 million pounds of the species landed by both fisheries were caught by sportsmen compared to 56 million caught commercially. This sports catch represents about 14 percent of the total marine fishery resource of Massachusetts. The minimum value of these catches were, as Crutchfield notes, their equal per pound to the commercially landed catch. However, including other expenditures on a total of over 600, 000 fishing trips, these landed sportfish represented a far greater economic impact than just their landed value.

Consumer Surplus and Demand Analyses. Regrettably, no sophisticated benefit analyses exist for estuarine recreation though such analyses are currently being developed for recreation areas in several interior regions of the country. They require much data on the behavior of recreationists and the factors behind their decisions to visit a given recreation area at a particular time. Such data are difficult to collect and require large inputs of time and money. In return for the effort, however, economists are able to measure the economic effect of investment in recreation on the users of recreation facilities. **

User-Days Fixed Recreation Benefits. Out of the confusion that developed following the first federal attempts at quantifying recreation benefits, a ssystem of values was agreed upon for use in federal water-resources projects. The method adopted assigns a fixed value for a user-day or participation-day of recreation activity. The range of values selected were representative of the amount that users would be willing to pay for particular recreation activities, should such payments be necessary. The user-day recreation-benefits approach has been widely criticized by economists as being arbitrary and unsensitive to the economic factors relevant to recreation-demand analysis.

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*Op cit, p 152.

**See, for instance

(a) Clawson and Knetsch, Economics of Outdoor Recreation, The Johns Hopkins Press (1966).

(b) Seckler, David W., On the Uses and Abuses of Economic Science in Evaluating Public Outdoor Recreation, Land Economics (November, 1966), pp 485-494.

(c) Lerner, Lionel J., Quantitative Indices of Recreational Values, Economics in Outdoor Recreation Polity, Report No. 11, Committee on Water Resources and Economic Development of the West, Western Agricultural Economics Research Council (1962).

(d) Knetsch and Davis, Comparisons of Methods for Recreational Evaluation, in Water Research, Johns Hopkins Press, 1966.

Principal use of the user-day approach has been in federal waterway and reservoir projects. It has received little application towards estuarine recreation with the major exception of an analysis of recreation and fisheries on San Francisco Bay.* Net benefits for general recreation activities, by this method, range from $0.50 to $1.50 per user day. Specialized activities are valued higher. The San Francisco Study used medium unit values for recreation participation, as follows:

TABLE A-19. MEDIUM UNIT VALUES FOR RECREATION PARTICIPATION

Activity	Dollars per Participation Day			
	1960	1965	1970	1980
Sunbathing and swimming	1.00	1.00	1.00	1.00
Sightseeing	1.00	1.00	1.00	1.00
Boating	1.50	1.50	1.50	1.50
Water skiing	1.50	1.50	1.50	1.50
Picnicking	1.25	1.25	1.25	1.30
Nature walking	1.00	1.00	1.00	1.00
Hunting	4.50	4.50	4.50	4.50
Camping	1.50	1.50	1.50	1.50
Hiking	1.00	1.00	1.00	1.00
Striped bass angling	3.50	3.50	3.50	3.50
Catfish angling	1.00	1.00	1.00	1.00
Miscellaneous bay angling	1.00	1.00	1.00	1.00
Ocean and bay salmon angling	6.00	6.00	6.00	6.00
River salmon angling	4.50	4.50	4.50	4.50
Unidentified delta angling	2.50	2.50	2.50	2.50
American shad angling	2.50	2.50	2.50	2.50
Steelhead angling	5.00	5.00	5.00	5.00
Largemouth black bass angling	1.50	1.50	1.50	1.50
Sturgeon angling	3.50	3.75	4.00	4.50

With the prevalent dissatisfaction toward this method of evaluating recreation benefits among resource economists, it is expected that the user-day approach will become less significant in the near future, in favor of more analytical demand analysis.

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*Stanford Research Institute, Recreation and Fishery Values in the San Francisco Bay and Delta, Report to FWPCA, 1966.

CONFLICTS IN RESOURCE USE

There are several serious conflicts which affect recreational activities in the use of estuaries. Although the literature widely discusses resource-use conflicts involving recreation, there are very few quantitative data actually expressing the degree to which resource conflicts detract from the use of estuaries for recreation. Most of the data in discussion of use conflicts are generally developed to support one side or the other in a particular conflict situation; therefore, there is little to be found in the way of objective conflict information.

Natural Factors

Few natural factors prohibit or reduce the use of estuaries for recreation. One of the most common types of natural inhibitors is the presence of undesirable marine species in the estuarine environment. A good case in point is the abundance of the sea nettle in much of the waters of the Chesapeake Bay. The sea nettle, and similar species, makes swiming in the waters of the Bay extremely uncomfortable and, therefore, highly undesirable. For this reason, much of the Chesapeake Bay, throughout a good portion of the summer recreation season, is virtually unused for swimming. Methods for eliminating pests of this type have not succeeded, although current biologic research is attempting to reduce the population of sea nettles in the Bay, and open up its waters for swimming. No estimates have been made of the losses in recreation value or potential due to the presence of sea nettles in the Bay, or to other pests in other estuarine waters.

A second important natural factor reducing the recreational usefulness of many estuaries is the natural character of the shoreline. Many estuarine areas are bounded primarily by marshlands, which have prohibited public access to the water, and some estuarine shorelines consist of high-bluff regions which, again, restrict access to the water. Although shoreline physiography has played a role in determining the extent and nature of recreation in some estuaries, modern methods of land development and construction are generally able to overcome such problems. Usage of estuaries for outdoor recreation has been restricted by man's activities on estuaries and development of land adjacent to estuaries far more than it has been by natural causes.

Pollution

Swimming. Estuaries are widely used as the receiving bodies of water as discharges for man's domestic and industrial wastes. With this use has developed a degree of pollution in many estuaries which is considered to be unsuitable for human-contact activities, notably swimming. Public health and sanitation officials seem to be in some disagreement as to the degree of pollution that is detrimental to human health via water contact. There are few verified cases where human illness has developed as a result of swimming in polluted estuarine waters. However, all states and most municipalities have sanitation codes pertaining to swimming beaches which restrict the use of polluted waters. Inasmuch as estuaries in proximity to major metropolitan areas receive the greatest waste loadings, beach closings in these areas are most common, and, therefore, most seriously affect large numbers of people. Because of their oscillatory flow patterns, many estuaries retain waste materials indefinitely and, thereby, seriously pollute beach and other coastal waters. In several large metropolitan areas, estuarine-located beaches must be closed for sanitary reasons, while beaches located facing the open sea remain unpolluted and hence usable. In Baltimore County, Maryland, the only beaches kept open during the 1967 recreation season were those directly facing upon the main water expanse of the Chesapeake Bay. On the other hand, all beaches located along smaller tributary inlets and estuaries in the vicinity of the Bay had to be closed because of municipal and industrial pollution. Several of the beaches in Baltimore County are directly affected by tidal action from the Patapsco River, which is the main estuarine route into Baltimore Harbor. These beaches are not directly located on the water bodies receiving direct sewage discharges, but due to tidal transport of water and waste material, they are nevertheless affected. Such tidal action carries pollution from many large industrial plants along the waterway as well. Because of proximity to a major seaport, local sanitation authorities are doubtful whether these bodies of water will ever be suitable for human-contact sports such as swimming. Their doubt extends even into the future when direct discharges of municipal and industrial wastes may be eliminated. *

Nutrient materials present in sewage effluents stimulate the growth of aquatic plants. Excessive plant growth, eutrophication, has long been a problem on inland bodies of water in Europe and in parts of the United States. Recent cases of eutrophication in estuarine waters have caused this to be a serious problem in the coastal regions as well. The Potomac Estuary is a notable example of excessive algae blooms causing a detrimental effect upon the environment of an estuary. Many of the small inlets and estuaries along the shores of the Chesapeake Bay are similarly affected by eutrophication. Decay of plant material is often responsible for obnoxious odors which inhibit uses of shoreline areas adjacent to estuaries. Excessive vegetation is detrimental to recreational boating and swimming, and causes serious deleterious effects upon estuarine fisheries.

There has been relatively little investigation of the actual relationship between recreational usage of an estuary and water pollution. Swimming is generally affected by pollution in a very absolute relationship. That is, either a bathing beach is open, and therefore in use, or else it is closed due to pollution. There is no experience in measuring the relationship between swimming usage of a particular estuary and the water quality at that estuary. It is known, however, that several estuaries in metropolitan areas on which swimming is prohibited due to pollution are nevertheless used for swimming by sections of the population.

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*News release, Baltimore County Department of Health, May 11, 1967.

Fishing. The relationship between water pollution on estuaries and sport fishing is far less absolute than it is for swimming. As water quality deteriorates in a body of water, there is a gradual replacement in species of highly desirable game fish by less desirable species. Finally, grossly polluted waters are inhabited by species which are totally undesirable for recreational fishing, or in the extreme, uninhabitable. Research to quantify and measure the relationship between recreational fishing and water pollution is barely in the exploratory stages. One study which has been done develops a methodology for estimating direct recreational benefits from water-pollution control through a model of biological and behavioral relationships involved in sports fishing. * A function was developed to relate angling effort and the output, or yield, of fish taken. Angling success per unit of effort was used to represent the quality of the recreational experience. Water pollution would cause deteriorations in dissolved oxygen, temperature, or toxicity characteristics of the water, thus shifting the production function downward and causing reductions in angling success, angling effort, and recreational value of the fishery. Demand equations and success-efforts relationships were estimated for three estuarine fisheries, and the methodology was illustrated by an assumed reduction in angling success. Research of this nature, which was conducted on Yaquina Bay, Oregon, represents a beginning in the determination of the relationship between recreational value and water pollution.

Boating. Although there are many contradictory statements and remarks concerning the relationship between recreational boating and water pollution, it appears evident that recreational boating is seldom inhibited due to water pollution. In extreme cases, where boaters have a choice of waters upon which to launch and sail their boats, there is a tendency to favor those waters that are less polluted and which cause least damage to their craft, all other things being equal. Similarly, there is some controversy as to the extent to which recreational craft cause polluted conditions on estuarine waters. It is unlikely that recreational boating is a major source of estuarine pollution, except in sheltered areas and coves with poor water circulation, or where there is a cluster of boats, such as at a marina or public launching area.

Conflicts Between Sport Fishing and Commercial Fishing

Considerable concern exists on the part of sport fishermen about the conflicting interest between sport and commercial fishermen. ** Most literature in the sport-fishing field calls for greater protection of the sport fishery. The economic comparisons presented, however, are generally invalid and usually misleading. In terms of actual number of fish caught and, therefore, the actual value of the fishery, commercial fishing in estuaries is still responsible for a greater catch than sport fishing.

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*Stephens, Joe B., Recreational Benefits From Water Pollution Control, Journal of Water Resources Research, Vol 2, No. 2 (1966), pp 167-182.

**Moss, Frank, Relations Between Sport and Commercial Fishermen, Proceedings, Eleventh International Game Fish Conference (1966).

However, most estimates of the value of sport fishing include all expenditures by fishermen for participation in the activity. This, when compared with the value of commercial catches, appears to present the fact that the sport-fishing activity is more valuable to the economy than the commercial activity. However, an analysis of comparable expenditures by commercial fishermen would probably indicate that, in terms of total dollars to the economy, commercial fishing is still the more valuable use of estuarine fishery resources. However, comparison of these figures does nothing to solve the real conflicts and problems between sport fishermen and commercial fishermen, i. e., the depletion of the fishery resource.

Responsible persons in both the sport fishing and commercial fishing activities are in agreement that it is to their mutual benefit to protect the fishery resource in estuaries, where it is particularly vulnerable to adverse environmental factors. Moss suggests* that if fishing as we know it today is to continue in the future for both sport and commercial fishermen, both sides are going to have to get together, settle differences, and join ranks to fight the "big battles". He identifies the following "big battles":

(1) The plunder of our continental shelves by fishing fleets of foreign nations (considered to be one of the most serious). He considers the new 12-mile fisheries-protection zone, as recently passed into law, to be insufficient to protect the food and mineral resources of the continental shelf.

(2) Attitudes on the part of sport fishermen and commercial fishermen, which do not recognize the valid activity of the other, also come into criticism by Moss.

He cites the problem in the menhaden industry of the Chesapeake region and the conflict in that estuary between bunker seiners and local sport fishermen. Sportsmen in that area have been quick to blame that industry's problems on overfishing by the commercial fisheries. The menhaden fishermen, on the other hand, have been especially vulnerable to restrictive legislation desired by elements among local sport fishermen who would like to see the industry driven out of the region altogether. Moss suggests that sport fishermen must start to recognize that attempts to get special-privilege legislation are being received negatively in most state legislatures. He reports that sportsmen do themselves more harm than good when they insist that the conservation of fishery resources means reserving the fish for sports fishermen. He suggests that the commercial-fishing industry could achieve new life by opening the membership of the various marine fisheries commissions to responsible sport-fishing representation. It is apparent that commercial and sport-fishing interests on estuarine waters have too much in common not to cooperate toward a common goal of improving fishery resources.

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*Ibid.

Reductions in Flow

Most estuaries depend upon inflows of fresh water from considerable land-drainage areas as an input into their total hydrologic system. Several large freshwater inflows to estuaries have been diverted for on-land use or consumption, thereby altering the flow balance in the estuarine portion of the basin. The consequences of these diversions are poorly understood by biologists and ecologists responsible for improving and preserving marine life in estuarine waters. A notable plan for major diversion of freshwater has been proposed as part of the Texas Water Plan, which would divert freshwater flowing toward the Gulf of Mexico to West Texas for irrigational use. The effect upon the estuaries on the Texas coast from the reduction in freshwater inflows is not known at this time and is cause for considerable concern among ecologists interested in those estuaries. Ecological relationships in estuaries of this type present an important data gap which must be overcome before proper hydrologic-ecologic management of river basins and estuaries can be achieved.

Another area for concern is at the headwaters of the Chesapeake Bay and its major freshwater inflow, the Susquehanna River. Presently, the Susquehanna constitutes the major freshwater source for Chespeake Bay, and particularly for its upper reaches. The Chesapeake-Delaware Canal, connecting the upper portion of Chesapeake Bay with Delaware Bay, is being improved to carry larger vessels. The improved canal will also divert flows from Chesapeake Bay into Delaware Bay. These flows will consist primarily of the freshwater inputs from the Susquehanna River, therefore causing a probable increase in salinity within most reaches of the Chesapeake Bay.

Tidal and hurricane barriers at the mouths of some estuaries restrict the interchange of flows to and from the open seas. The hydrologic and biologic significance of these restrictions is not fully understood.

Dredging and Excavation

Estuaries are generally dredged or excavated for three principal purposes:

(1) Navigation improvements

(2) Landfill and reclamation

(3) Mineral extration.

The dredging of estuaries for navigation improvements is closely related to landfill operations in that much of the spoil material from channel dredging is used in shoreline land reclamation. Land reclamation on estuaries is an ancient practice - one that proved very successful at many locations.* Dredging and landfill operations on estuaries provide many beneficial applications toward recreational activities. Recently, however, there has been wide publicity cast upon detrimental effects, to the point where the beneficial effects are often no longer considered. This discussion will attempt to highlight both the favorable and unfavorable effects from estuarine dredging and landfill. However, as for most other areas of estuarine use conflicts, there are few quantitative data available with which to evaluate the effects.

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*See Appendix E on Land Reclamation.

While the primary navigational dredging on estuaries takes place for the enhancement of commercial shipping, there are several estuarine areas at which channels are improved solely for the purpose of recreational boating. With these shallow-draft channels, new shoreline areas are opened up for recreational usage, and recreational boating is enhanced. Likewise, land reclamation on estuarine shorelines often creates recreation opportunities previously unavailable. New shoreline lands, although developed for many purposes, often are at least partially utilized for recreation. Generally, recreational communities located on shoreline-landfill sites contain, and often feature, the development of recreational facilities for use by local residents. Many of the new Florida communities on estuaries highlight the accessibility of aquatic recreation to the purchasers of new homes in the development. New marinas and other recreational areas are often located on such landfill sites. Marsh lands are converted to areas where new recreational development takes place and better access is afforded to the shoreline.

The primary argument against dredging and land reclamation on estuaries is the destruction of the estuarine habitat and environment through this process. Hearings before the subcommittee on Fisheries and Wildlife Conservation of the committee on Merchant Marine and Fisheries of The House of Representatives, 1967, spotlighted many arguments against the continuation of dredging of navigation channels in estuaries and the excavation of new channels. It is claimed that estuaries are the most productive areas of marine organisms, and, therefore, destruction of estuarine habitat causes serious depletion of commercial and sport fisheries, as well as all of the organisms necessary to support such fisheries. Land reclamation on estuaries reduces the total volume and area of such estuaries and may, in itself, cause serious problems within the marine environment. The most notable example of reduction of area due to filling is in San Francisco Bay, the size of which has been reduced by 50 percent through land-filling operations in recent years. While additional shoreline may present new recreation opportunities, reduced estuarine area may limit the number of participants and the types of activities for which an estuary may be used. Dredging also may uncover sludge beds and other contaminants which can adversely affect the estuarine biota.

In some estuaries, including Cheapeake Bay, there is a deficiency of land sites available for the disposal of spoil dredged from navigation channels. Navigation channels in estuaries on which major seaports are located must be constantly dredged and cleared to accommodate commercial shipping. The dredged material, or spoil, presents a serious problem in land and water use, particularly adjacent to urban areas where most shoreline has previously been developed. Removal of spoil is expensive, and its final location may be detrimental to the local marine environment. In fact, at the recent Maryland Governor's Conference on the development of the Chesapeake Bay, it was hypothesized that spoil disposal is the single most serious physical or environmental problem in the Chesapeake Bay. *

Mineral-extraction activities are generally far enough offshore to present few problems to recreational usage of estuaries. One exception is for the dredging of shells from estuaries as a source of aggregate, calcium, and other minerals. Such dredging has a detrimental effect upon the local environment and may seriously reduce an estuary's production of finfish and shellfish. One estuary where this problem is particularly serious is in the Galveston-Trinity-East Bay-Estuarine Complex along the Gulf Coast of Texas. At present, there are approximately 60 million cubic yards of recoverable shell remaining in these estuaries. ** It is estimated that the shell supply will become exhausted by the fall of 1970. The alternative to using and dredging the shell deposits is to mine limestone deposits on land, which are a greater distance, with greater transportation cost, from the area presently being served by the shell deposits.

On the other hand, it is feared that dredging of oyster shells from this Texas estuarine complex inflicts serious biological effects upon the productivity of the estuary complex. It is estimated that over 6 million fisherman days are spent in this estuary complex, accounting for 32 million pounds of sport fish caught per year. It is feared that the shell dredging, a temporary activity, will permanently damage the environment of this estuary system. Similarly, the U. S. Bureau of Commercial Fisheries indicates that the present commercial-fishery harvest in this region could be increased immediately by about 50 percent, with cessation of the dredging. Similar situations exist in other estuaries with high shellfish production.

In summary, it must be noted that estuaries are rarely used solely for recreation. Because of multiple uses of estuaries and their shorelines, there are, and will continue to be, conflicts between recreation uses and other uses. However, if pollution of estuaries is reduced and other adverse environmental interactions avoided, there is no reason why estuaries cannot continue to be used for recreation as well as for a multitude of other uses. It would seem appropriate to consider zoning techniques for estuarine water areas and for shoreline land areas to make the coexistence of recreation and commercial activities on estuaries profitable and enjoyable.

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*September 12-13, 1968.

**Sport Fishing Institute Bulletin, No. 184 (May 1967), pp 5-7.

Conclusion

The future development and management of estuaries for recreation by the public sector may be based on data which are presently not suitable for statistical analysis. Private investors may use projections of sales, expenditures, and regional impacts to make their decisions but as a major criterion for public investment, user benefits, has hardly been developed for estuarine recreation. Furthermore, there has been little effort to compare the return on public investment from estuarine recreation development with comparable development in other regions of the country.

Many of the problems now confronting estuarine recreation use are conflicts between users. These conflicts will have to be handled through a program of estuarine management, preferably under the authority of a regional organization. To achieve effective management, more must be learned about the effects that human activities have on the natural environment. In short, what we now know about the physical and economic aspects of estuarine recreation is not likely to be sufficient to assure that future development and management of estuaries for recreation is fully responsive to the demands on the estuarine resource.

APPENDIX B

THE FUTURE ECONOMIC VALUE OF ESTUARINE-DEPENDENT COMMERCIAL FISHERIES

Granville H. Sewell and Robert F. Hillman

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APPENDIX B

THE FUTURE ECONOMIC VALUE OF ESTUARINE-DEPENDENT COMMERCIAL FISHERIES

by

Granville H. Sewell and Robert F. Hillman

SUMMARY OF CURRENT SITUATION

In 1967, United States fishermen received approximately $438 million for about 4.06 billion pounds of commercial fish and shellfish.* While 7 percent less in dollar value than the 1966 catch, this 1967 harvest of sea products still registered 16 percent- about balancing the inflationary trend - more in value than the previous 10-year average and can be considered representative of the overall trend for the United States commercial fisheries.

Comparison of a list of estuarine-dependent fish species prepared by Dr. J. L. McHugh with the 1967 catch by species indicates that approximately two-thirds of the total value, or approximately $300 million, can be considered derived from estuarine - dependent species.** This gross indication of estuary value, though, is undoubtedly conservative since it omits the value of estuarine-dependent fish harvested off the United States coast by foreign fishing vessels, and it does not include estuarine - dependent species from the estuaries of other nations but imported into the United States. Furthermore, the term "estuarine-dependent" includes a vast spectrum of biological relationships, and even some continental-shelf species, such as bluefish, and marine predators, such as tuna, can be considered dependent upon the estuary as an ultimate source of most of their food.

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*Charles H. Lyles, Fisheries of the United States...1967, C.F.S. No. 4700 (April, 1968), p 4.

**J. L. McHugh, "Management of Estuarine Fisheries", A Symposium on Estuarine Fisheries, American Fisheries Society Special Publication No. 3 (1966), p 134.

For estimates of estuarine-dependent fisheries on a regional basis, see:

James E. Sykes, "Commercial Values of Estuarine-Generated Fisheries on the South Atlantic and Gulf of Mexico Coasts", Proceedings of the Marsh and Estuary Management Symposium (July 19-20, 1967), p 74.

B.E. Skud and W.B. Wilson, "Role of Estuarine Waters in Gulf Fisheries", Transactions of the 25th North American Wildlife Conference (1960), pp 320-326.

John Clark, Fish and Man: Conflict in the Atlantic Estuaries, Special Publication No. 5, American Littoral Society, Highlands, N.J. (1967), p 24.

The future economic value of the estuarine-dependent species for the United States commercial fishing industry will depend upon at least three major forces now significantly influencing trends: (1) the shifting market demand for fishery products in the United States, (2) the state of the commercial fishing industry on a worldwide basis, and (3) the compatibility between evolving conditions in the United States estuaries and the production of adequate fishery stocks. Each of these trends is characterized by numerous complicating circumstances, by a lack of descriptive data, and by rapidly changing factors. The objectives of this report is to describe and, where possible, evaluate the nature of the forces and implications of possible future trends.

MARKET DEMAND FOR FISH PRODUCTS

Domestic market demand in recent years has been dominated by (1) rapidly expanding sales of industrial fish products and (2) shifting demand in edible species from staple to luxury or convenience categories, though the per-capita demand for edible fish products has remained almost static at about 10.5 pounds for at least 50 years.*

Industrial Fish Products

After a period of relative stability, the United States Consumption of industrial fish products rose almost steadily from a catch weight of 3.2 billion pounds in 1958 to 9.1 billion pounds in 1967.** Yet the domestic industrial fish catch fell from 2.1 to 1.7 billion pounds during the same period. Imports filled the gap, representing 35 percent of the total United States supply in 1958 but 82 percent in 1967 (see Figure B-1).

Fish oil, fish solubles, and fish meal are the primary industrial fishery products in the United States market with fish meal being the principal item.*** The poultry industry consumes about 75 percent of the fish meal as a feed component for broilers, and the bulk of the fish oil competes directly with vegetable oils in the international edible oils market,**** about one-third of domestic production remaining in the United States for nonedible uses. The growth in fish-meal consumption follows the spectacular fall in wholesale prices for poultry, particularly broilers, relative to wholesale prices for all commodities. The wholesale price index shifted from 171.1 in 1950 to 92.0 in 1966, a drop of 46.2 percent using wholesale prices for all commodities in 1957-1959 as the index of 100.[†] By comparison, wholesale fish prices rose 29.4 percent during the same period while meat prices fell 13 percent.

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*Lyles, op. cit., p 60.

**Ibid, p 53.

***In 1967, the supply of fish meal was 1,726 million pounds; fish solubles, 156 million pounds; and fish oils, 50 million pounds.

****For a thorough discussion of projected demand, see: Bureau of Commercial Fisheries, Projected Needs for Fish Products, Issue Paper No. 1, unpublished (May, 1967).

Nevertheless, prices for fish meal have been declining, dropping from an average of $163.65 per short ton (New York City) in 1966 to $140.15 in 1967, for menhaden meal.[‡] Future declines in broiler prices with corresponding increases in poultry's share of the protein market may occur but past performance is unlikely to be matched because of the high conversion efficiency of feed to meat already being achieved. Also, use of substitutes for fish meal in broiler feeds is becoming more widespread. Hence, the fish-meal market, on a tonnage basis, will probably continue to climb at a diminished rate in the immediate future.

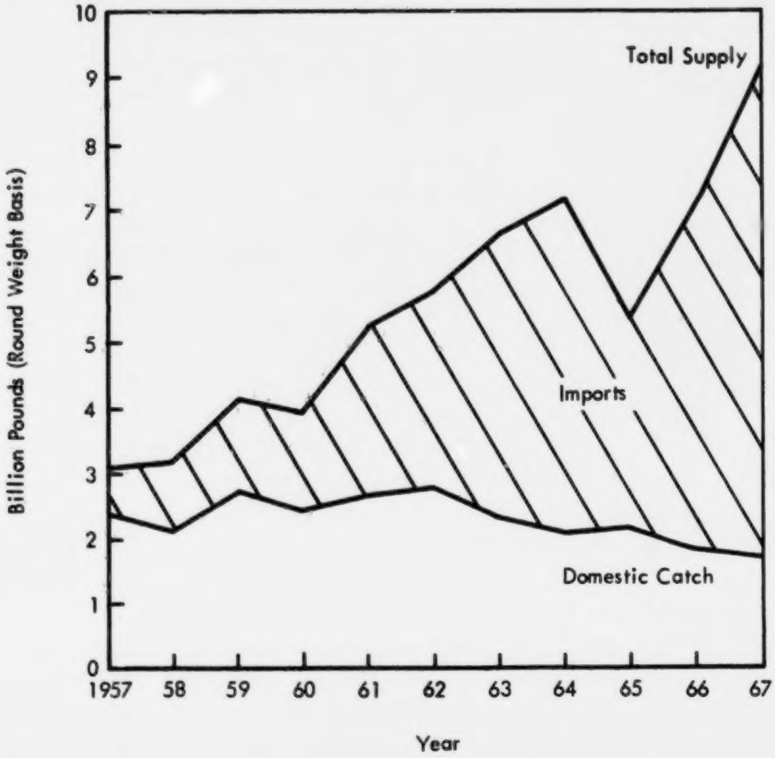

Figure B-1. United States Supply of Industrial Fishery Products

Source: Lyles, Fisheries of the United States...1967, Bureau of Commercial Fisheries C.F.S. No. 4700.

In the extended future - beyond possibly 5 years - the outlook for the industrial fish market is confused. On one hand, vast new markets may be opening in extended feed-lot operations for live stock and in production of new products, particularly FPC

[†] Ibid., p 9.

[‡] Bureau of Commercial Fisheries, Industrial Fishery Products: 1967 Review, Current Economic Analysis I 1 (April, 1968), p 4.

(fish protein concentrate), which is slowly overcoming technological difficulties and bureaucratic proscriptions. On the other hand, numerous protein substitutes, including petroleum and soybean derivatives, are under development and the market for industrial fish at a price attractive to United States fishermen may further diminish. Part of the answer lies not in the protein derivative market but in the ability of United States fishermen to lower production costs through technical innovations and through introduction of new species to the market.

Both developments appear possible. As noted later, the abundant stock and schooling characteristics of the herring-like or clupeoid fishes sought for the industrial market do permit the development of economies of scale through vastly improved and enlarged equipment, automation, and specialization by fishery technicians. Also, promising new species have been identified, such as the thread herring (Opisthonena oglinum) of the Gulf of Mexico.* Estimates by J.A. Butler indicate that the existing thread-herring stocks could supply a minimum annual catch of 1 billion pounds.**

On the basis of income and population projections, the Bureau of Commercial Fisheries' economists in 1966 made a series of market projections for industrial fish in the United States. From a 1966 base market of 7.04 billion pounds, their "moderate" market projection was for utilization of 10.2 billion pounds in 1973, 12.8 in 1985, and 16.1 in 2000. Since the market has already absorbed 9.1 billion pounds in 1967, these estimates are probably low.

Edible Fish Products

Though per-capita consumption of edible fish products has been virtually static, population growth caused the market to expand from 4.3 to 5.1 billion pounds between 1957 and 1967. The additional demand has been met by imports, the domestic catch shrinking from 61 percent of the total supply in 1958 to 47 percent in 1967. The composition of the total supply, though, has shifted, and the inroads made by imports have been selective by species.

Shrimp, which had represented about 10 percent of the edible fish products by weight on the market in 1957, rose to about 20 percent by 1967. While 36 percent of the shrimp in 1957 was imported, this had risen to 51 percent by 1967. Tuna was another fishery product gaining substantial favor among housewives, extending its market from about 36 percent of all fishery products to 41 percent during the decade. Imports of tuna rose slightly from 42 percent to 51 percent. Salmon and sardines were the principal losers among fish species, with catches of other species remaining approximately the same in volume. All species, however, were more often found at the grocery stores in a more highly processed form. Slightly less than 83,000 pounds of prepared fish sticks and portsions were sold in 1957, while the corresponding figure for 1967 was over 232,000 pounds. Production of breaded shrimp increased from 39,000 in 1957 to 93,000 in 1967.

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*Sykes, op. cit., p 76.

**J.A. Butler, "Development of a Thread-Herring Fishery in the Gulf of Mexico", Commercial Fisheries Review, 23 (9), 12-17 (1961).

Three factors are particularly likely to influence the future edible-fish market in the United States: prices, changing tastes, and world supply. As described in Figure B-2, the competitive position of fish has been hampered by a rising market price relative to its primary protein competitors, meat and poultry. If beef and other meat prices rise substantially in the future, as some market specialists anticipate, fish may partially regain its standing as an economy food item and sales could rise.* Thus, a rise in demand for edible fishery products proportionate to population increase appears reasonable. And, as incomes increase, the popularity of more delicate fish products, such as shrimp, can be expected to continue increasing as long as a stable price and adequate supply remain. In a few cases, particularly salmon, a shrinking world supply appears to dictate a declining market that is not responsive to price rises.

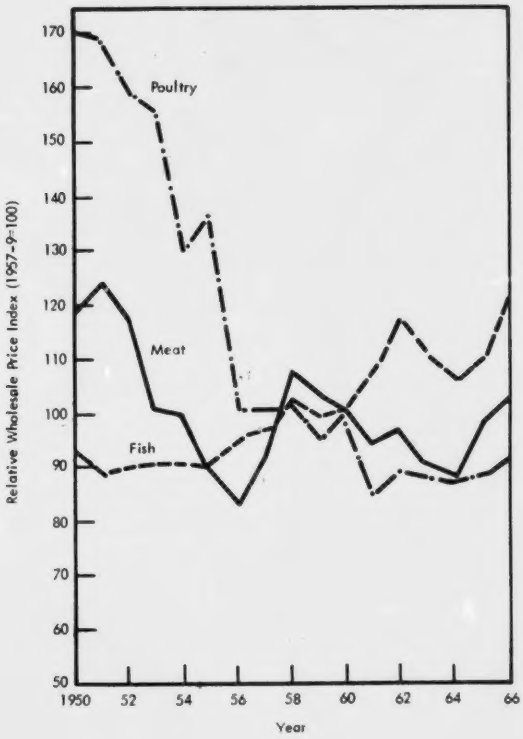

Figure B-2. Wholesale Price Index for Poultry, Fish, and Meat as Deflated by Wholesale Price Index for All Commodities, 1950-66

Source: Bureau of Commercial Fisheries, Projected Needs for Fish Products, Issue Paper No. 1, Unpublished (May, 1967), p 9.

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*For a thorough discussion of income elasticities for fish and competitive protein sources, see Bureau of Commercial Fisheries, Projected Needs for Fish Products, Issue Paper No. 1, unpublished (May, 1967).

On the basis of a series of projections which took many of these issues into account, economists at the Bureau of Commercial Fisheries estimated that consumption of edible fish and shellfish products should reach 5.9 billion pounds in 1973, 7.8 in 1985, and 12.0 in 2000.*

TRENDS IN THE WORLD FISHERIES

In 1967, over 70 percent of the United States supply for all fishery products was attributed to imports, compared with 33 percent in 1957.** On a worldwide basis, United States imports accounted for approximately 40 percent of the entire world trade in fish products.*** This trend towards imports could be reversed if (1) the differences in production costs between the United States fishing industry and foreign competitors were diminished; (2) demand in other nations rose, increasing world prices and diverting imports elsewhere; or (3) the supply obtained from a particular fishery was suddenly reduced by war or natural disaster. In any case, a reduction of imports that increased reliance upon estuarine-dependent species in the United States would mean a corresponding rise in the apparent value for maintaining adequate estuarine conditions.

Production Costs

The existing gap in production costs between United States fisheries and foreign competitors could be reduced by either a relative rise in costs, particularly in labor, for the foreign producers or a relative rise in efficiency among American fishermen. Both represent realistic possibilities for the future. The differences in production costs are frequently drastic and are reflected in landing prices. For example, cod in the United States typically brought 8.62 cents per pound on the market in 1965 but 3.89 cents (U.S.) per pound in Canada.**** Hake brought 6.42 cents in the United States, 2.63 in Canada; flounders, 9.96 in the United States, 3.04 in Canada. However, the rise in consumer prices in major fish-producing countries during this decade has generally favored the United States - though this trend may not be maintained during the current inflationary period for the United States. In 1965, consumer prices in Japan rose about 8 percent over the previous year; in Italy, 5.5 percent; in Norway, 5.3 percent; in Spain, 16.3 percent; and in the United States, 1.3 percent.***** Between 1958 and 1965, wage rates rose by 77 percent in Japan, 62 percent in Italy, 62 percent in Norway, and 24 percent in the United States.

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*Ibid., p 19

**Lyles, op. cit., p xx.

***Bureau of Commercial Fisheries, Structure of the U.S. Commercial Fishing Industry, Issue Paper No. 3, unpublished (May, 1967), p 2.

****Bureau of Commercial Fisheries, Sources of Supply for Meeting U.S. Demand for Fish and Shellfish Products, Issue Paper No. 2, unpublished (May, 1967), p 20.

*****Ibid., p 21.

The American fishing fleet has been sharply criticized for backwardness in both equipment and manpower quality. Among the evidence cited is that the United States has the greatest number of reported powered fishing craft of any nation except Japan but ranks seventh (after Japan, U.S.S.R., W. Germany, Spain, Italy, and Iceland) in the estimated number of modern, large-scale, high-seas fishing vessels over 500 gross tons (see Table B-1). Only 5 percent of United States vessels are constructed of steel, and during a survey performed in 1962, less than half were reported having as elementary a piece of equipment as a depth finder.* A change is occurring gradually. In 1967, 13 vessels - more than estimated for the entire United States fleet in 1965 - out of 869 added to the fishing fleet exceeded 500 gross tons, and about 30 percent were constructed of steel instead of wood or plastic. Because of the relatively short distance to many fishing grounds, lack of large steel vessels per se is not an absolute indicator of inefficiency. However, coupled with statistics of the fishing labor force, an image of backwardness akin to the pre-World War II agricultural sector in the United States emerges.

TABLE B-1. ESTIMATED NUMBER OF MODERN, LARGE-SCALE, HIGH-SEAS FISHING VESSELS OF OVER 500 GROSS TONS FOR SELECTED COUNTRIES OF THE WORLD

Country	Year for Which Data Apply	Estimated Number of Fishing Vessels Over 500 Gross Tons	Total Gross Tons	Average Gross Tons/Vessel
Japan	1964	260	730,000	2,812
U.S.S.R.	1965	246	922,644	3,751
W. Germany	1965	155	131,400	848
Spain	1964	102	n.a.	n.a.
Italy	1964	79	45,000	570
Iceland	1966	45	29,566	657
U. S.	1965	12	7,720	643

Source: Bureau of Commercial Fisheries, Structure of the U.S. Commercial Fishing Industry, Issue Paper No. 3, unpublished (May, 1967), p 8.

In a 1963 census of commercial fisheries, nearly 90 percent of all operations were conducted with less than five employees. Their average annual gross receipts were $16,319, and their total gross receipts accounted for less than half the receipts by the entire industry.** Out of this average of $16,319, the boat owner presumably had to cover wages and costs for operation, capital, and maintenance. As could be anticipated from this situation, the average commercial fisherman during the past decade has been a relatively untrained, poorly paid individual. His numbers peaked about 1950 when 161,463 fishermen were included in the census but had declined to 130,431 in 1963 though a slight increase raised the number to an estimated 135,636 in 1966.* Between 25 and 35 percent of these fishermen were defined as "casual" fishermen who received less than one-half of their annual compensation from fishing.

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*Data from a private survey performed by Fish Boat magazine.

**U.S. Department of Commerce, Bureau of the Census, 1963 Census of Commercial Fisheries.

In any case, the 1960 census data suggest that commercial fishermen comprised an economically disprivileged category. Mean earnings per experienced male worker in the fishing industry were $2,395 compared with the national average for all industries of $4,621.** Furthermore, their status deteriorated in some aspects between the 1950 and 1960 censuses, the percent unemployed rising 6 percentage points and the proportion of workers employed for 50 to 52 weeks declining 4.2 percentage points to 32.5 compared with 68.8 percent for all occupations. Yet full-time fishermen in the Boston haddock fleet worked an estimated average of 3,192 hours in 1964 compared with 2,168 hours in manufacturing.*** The median age of the Boston fishermen was 57 years. About three-quarters had not completed grade school, and only about 13 percent held a high school diploma.

This equipment and labor situation depicts a fragmented, passive, and aging industry that resembles mining and agriculture before economic pressures, specialized technicians, and (in the case of agriculture) government-spurred research precipitated drastic restructuring. Several indicators suggest that this situation may change. Articulate individuals are arguing for more-professional development.**** The United States Government is encouraging innovation through new programs, including subsidies.* And, physically, the older generation must gradually fade from the field, opening opportunities for younger, more aggressive professionals. Improved efficiency, reflected in relatively lower production costs, will inevitably result.

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*Lyles, op. cit., p 15.

**Bureau of Commercial Fisheries, Structure of the U.S. Commercial Fishing Industry, Issue Paper No. 3, unpublished (May, 1967), p 26.

***U.S. Department of Commerce, Bureau of the Census, 1960 Census of Population.

****Harvey R. Bullis, Jr., "Fishery Challenges in the Gulf and Caribbean", Paper presented to the GURC Seminar, New Orleans (September 8, 1966).

World Demand for Fishery Products

The international market for fishery products is in rapid transition because of an extraordinarily swift expansion of supply. In the decade between 1956 and 1966, the world fish and shellfish catch rose from about 30 to 56 million metric tons, an increase of 87 percent, or about 6 percent annually compounded.** During the same period, the world's population rose about 20 percent, or 1.6 percent annually.*** With continuing absolute economic development throughout the world and the anticipated rise in demand for proteins, the annual increase in demand for protein foods is expected to be a minimum of 3 to 4 percent and could easily exceed the 6 percent of fishery growth because of the vast population base involved. Furthermore, as the more accessible untapped fishing grounds are developed, the rate of fishery growth will probably decline.

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*Five Federal Laws provide the basis for current efforts to rejuvenate the fishing industry:

1. The Fish and Wildlife Act of 1956 authorized a Fisheries Loan Program which through 1967 had funded 1,066 applications with a value of $24,957,653.
2. The Fishing Vessel Mortgage Insurance Program provides insurance for financing of construction, reconstruction, or reconditioning of fishing vessels. During 1967, 36 mortgage insurance applications were approved for $10,147,720.
3. P.L. 86-516 established the Fishing Vessel Construction-Differential Subsidy Program which was extended by P.L. 88-498, the United States Fishing Fleet Improvement Act, of August, 1964. To qualify, a fishing vessel must be of advanced design which will enable it to operate in expanded areas and must be equipped with newly developed gear. It could not be operated in a fishery where economic hardship would be caused to efficient vessels, and a public hearing must precede each application approval. Through 1967, 26 contracts have been executed under the program for a value of $15.5 million.
4. P.L. 88-309, the Commercial Fisheries Research and Development Act of 1964, provides for research to conserve fishery resources and improve the economic status of the fishing industry. During 1966 and 1967, $4.1 million was made available.
5. P.L. 88-304, the Anadromous Fish Act of 1965, authorized federal funds for conservation, development, and enhancement of the nation's anadromous fishery resources, including those of the Great Lakes. By the end of 1967, slightly more than $1 million was made available to non-Federal agencies on a 50 percent sharing basis.

Source: Lyles, op. cit., pp 68-69.

**Food and Agriculture Organization, Yearbook of Fishery Statistics: 1966; Catches and Landings, Vol. 22, Table A2-1, Rome (1967).

***United Nations, Demographic Yearbook: 1967, Table 1, Paris (1968).

Sudden Changes in Supply

Some of the newly developed fisheries of the world rest upon delicate international or natural circumstances. An outstanding example is Peru's fish-meal exports. Besides the arbitrary extension of territorial waters, Peru's fisheries are almost totally dependent upon the nutrient-rish Humboldt Current and southerly winds. Historically, however, these oceanographic and meteorological conditions have been fickle, shifting inexplicably with disastrous results upon local ecology and Peruvian fisheries. Yet the United States imported 68 percent of its fish meal from Peru in 1967.* On a more extended time basis, the same problems of polluted, diminished estuaries plaguing the United States can be expected to occur in foreign estuaries.**

ESTUARINE DEPENDENCY OF UNITED STATES COMMERCIAL FISH SPECIES

Estuarine dependence is a convenient term to describe a normally complex biological interrelationship between the estuarine environment and an aquatic organism. In actuality, the degree of dependence varies widely according to the type of dependence, the particular species involved, and even the geographical and climatic circumstances. Usually three or four fundamental types of dependence can be identified.***

1. Truly Estuarine Species

A few commercial species appear to be restricted entirely to the estuarine habitat, never entering fresh water or the high-salinity sea. The Virginia oyster (_Crassostrea virginica_) is the most important example, others - such as the striped killifish (_Fundulus majalis_) and the skilletfish (_Gobiesox strumosus_) - being more significant ecologically than commercially.

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*Lyles, op. cit., p 35.

**P. Korringa, "Estuarine Fisheries in Europe as Affected by Man's Multiple Activities", _Estuaries_, H. Lauff (Ed.), American Association for Advancement of Science, Washington, D.C. (1967).

***In _Fish and Man_, Clark described three general patterns for Atlantic fish: (1) the Residents, which will live most of their lives in the estuary and are exemplified by the spotted sea trout; (2) the Outsiders, which are primarily marine but are dependent upon the estuary for nursery, as in the cases of bluefish, fluke, menhaden, and king whiting; (3) the Insiders, the migratory fish that even spawn in the estuaries as well as depend upon the estuarine zone for nursery grounds. Examples would be the weakfish, red fish, mullet, and black drum.

In "Estuarine Nekton", (_Estuaries_) McHugh describes the four categories explained in the text above plus two other types of relationships, fresh water fishes that enter brackish water and adventitious visitors, which occasionally can be found in the estuarine environment but cannot be truly described as estuarine-dependent. Examples would be the bluefish, the albacore, and some of the jack fishes.

2. Anadromous and Catadromous Species

Salmon, the second most valuable United States fishery, is dependent upon the estuarine zone as a passage between the freshwater spawning areas and the saltwater environment where most of the salmon's life is passed. Numerous other such species, such as the striped bass (Roccus saxatilis) exist, but their commercial importance does not approach the level of salmon. Even fewer species, such as the American eel (Anguilla rostrata), are catadromous, living in fresh or brackish water during their adult stage but returning to saltwater for spawning.

3. Seasonally Estuarine Species

Many species, such as the striped anchovy (Anchoa hepsetus) and the spotted hake (Urophycis regius), are estuarine residents on a seasonal basis, consistently depending upon the estuarine environment to provide food and, in some cases, spawning areas during a significant part of the year.

4. Marine Species Using Estuary as a Nursery

In both value and weight, the most important generic kinds of marine resources (shrimp and menhaden) are dependent upon the estuary to provide shelter and food during the juvenile stage of their development. Spawning occurs at sea, not in the estuary, but adults would presumably not develop if the estuarine stage of the life cycle were thwarted.

RELATIVE IMPORTANCE OF DIFFERENT ESTUARINE-DEPENDENT FISHERY RESOURCES

When ranked by weight, five of the six leading generic kinds of marine resources caught by United States commercial fishermen in 1967 could be considered estuarine-dependent: menhaden (1.17 billion pounds), crabs (0.32 billion pounds), shrimp (0.31 billion pounds), salmon (0.21 billion pounds), and flounder (0.11 billion pounds) (see Table B-2.)* These five fisheries encompass over half of the United States commercial fish landings by weight.

When ranked by value, four of the leading six were estuarine-dependent and these four represented 48 percent of the total catch value: shrimp ($103.1 million), salmon ($48.6 million), oysters ($31.6 million), and crabs ($27.1 million).* Shrimp value alone almost equals the other three and accounts for 24 percent of the value of the entire United States catch. Shrimp are also a primary food item for other fish species, such as the spotted seatrout (Cynoscion nebulosus), and thus contribute indirectly to these other commercial fisheries.

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*The crab landings include the king crab, which is not an estuarine-dependent species.

TABLE B-2. RANKING OF THE TEN MOST IMPORTANT COMMERCIAL FISHERIES IN THE UNITED STATES DURING 1967

By Weight, thousand pounds			By Value, thousand dollars		
Rank	Kind	Weight	Rank	Kind	Value
1	Menhaden	1,165,800	1	Shrimp	103,100
2	Tuna	329,000	2	Salmon	48,600
3	Crabs	316,000	3	Tuna	44,514
4	Shrimp	312,200	4	Oysters	31,600
5	Salmon	206,400	5	Crabs	27,100
6	Flounder	110,900	6	Lobsters	24,100
7	Haddock	98,500	7	Clams	19,000
8	Sea Herring	85,100	8	Menhaden	15,200
9	Ocean Perch	71,500	9	Flounders	13,600
10	Anchovies	69,600	10	Haddock	10,500
	Total	2,765,000		Total	337,314

Source: Lyles, Fisheries of the United States... 1967.

ESTUARINE DEPENDENCE OF SHRIMP

Commercial shrimp are primarily drawn from two groups of decapod Crustacea, the Caridea and the Penaeidae. The Caridea bear their eggs externally, are generally less prolific than the Penaeidae, and are caught in only small numbers for the United States market. Examples would be the deep-water Pandalus borealis of the North Atlantic and the estuarine Crago franciscorum of San Francisco Bay. The bulk of United States catch consists of the generally more prolific penaeidean shrimps, with the estuarine-dependent species predominating.

About 60 percent of the entire United States shrimp catch is comprised of the brown shrimp, Penaeus aztecus. The white shrimp (P. setiferus) stocks vary widely from year to year but typically provide between 20 and 25 percent of the catch, while the pink shrimp (P. duorarum) is a source for possibly 10 to 15 percent.* These species are concentrated commercially in the Gulf of Mexico and adjacent waters. In each of these penaeidean species, the basic life cycle falls into Category 4 of the estuarine dependences described previously. Using the pink shrimp as an example, spawning occurs in offshore waters at depths of 100 to 150 feet, salinity between 36.1 and 37.7

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*Joseph H. Kutkuhn, "The Role of Estuaries in the Development and Perpetuation of Commercial Shrimp Resources", A Symposium on Estuarine Fisheries, Special Publication No. 3, American Fisheries Society, Washirgton, D.C. (1966).

ppt (parts per thousand), and temperatures between 18 and 25 C.* After 13 or 14 hours, the eggs hatch and the larval shrimp begin to pass through a series of developmental stages, at the same time beginning to move or drift towards the Florida mainland about 100 miles distant.** Movement to the estuary is believed to take from 3 to 5 weeks and, despite the large numbers of postlarvae entering the estuary, only an estimated 0.05 percent or less of the eggs produce shrimp that survive to this stage.***

By the time the estuary is entered, the postlarvae have developed from planktonic to benthic feeders and have developed a wide tolerance to varying salinity and temperature conditions.**** From about 2 to possibly 9 months, the juvenile shrimp grow rapidly from perhaps 1/2 inch in length to commercial size before returning to the sea and completing the life cycle.

While the life cycles of the three primary commercial species are similar, the species differ in their penetration of the estuary and their utilization of the estuarine environment after the adult stage is attained. The most valuable species, the brown shrimp, spawns in waters 150 to 230 feet in depth and remains a relatively short time in the estuary. The second most valuable species, though, is the white shrimp which rarely is found in waters with a depth greater than 100 feet and possesses a greater affinity for freshwater sources than do the other two species. For instance, a correlation between drought and a decline in white-shrimp stocks has been noted.† Conversely,

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*Albert C. Jones, Dolores E. Dimitriou, Jay Ewald, and John H. Tweedy, "Distribution of Pink Shrimp Larva (Penaeus duorarum) Burkenroad in Waters of the Tortugas Shelf, Gulf of Mexico", unpublished manuscript of the Institute of Marine Sciences, University of Miami (1964).
E.S. Iversen and C.T. Idyll, "Aspects of the Biology of Pink Shrimp (Penaeus duorarum)", Transactions of the American Fisheries Society, 89 (1), 1-8 (1960).

**Sheldon Dobkin, "Early Developmental Stages of Pink Shrimp (Penaeus duorarum) From Florida Waters", U.S. Fish and Wildlife Service, Fisheries Bulleton 190, 321-349 (1962).
Joseph J. Ewald, "The Laboratory Rearing of Pink Shrimp (Penaeus duorarum) Burkenroad", Bul. Mar. Sci. Gulf and Carib., 15 (2), 436-449 (1965).

***J.L. Munro, A.C. Jones, and D.Dimitriou, "Abundance and Distribution of the Larvae of the Pink Shrimp (Penaeus duorarum) on the Tortugas Shelf of Florida", unpublished manuscript of the Institute of Marine Sciences, University of Miami (1967).

****C.P. Idyll, D.C. Tabb, and B. Wokel, "The Value of Estuaries to Shrimp", Proceedings of the Marsh and Estuaries Management Symposium (July, 1967), pp 83-90.

†Henry H. Hildebrand and Gordon Gunter, "Correlation of Rainfall with the Texas Catch of White Shrimp", Transactions of the American Fisheries Society, 82, 151-155 (1953).
Robert H. Parker, "Changes in the Invertebrate Fauna, Apparently Attributable to Salinity Changes, in the Bays of Central Texas", Journal of Paleontology, 29 (2), 193-211 (1955).
Percy Viosca, Jr., "What Became of the White Shrimp?", Louisiana Conserv. Rev., 10 (7-8), 17-18 (1958).

an exceptionally large influx of fresh water has been shown to stimulate stocks.[*] These correlations, of course, may be related to the nutrients carried by the fresh water as well as to the change in salinities, but further research has indicated that salinities are important both for survival and growth. Furthermore, the toleration of different temperatures is related to the salinity.

Another commercial species (possibly as much as 2 percent of the catch) is the seabob (*Xiphopeneus kroyeri*) which completes its total life cycle in a narrow coastal zone, rarely penetrating the estuary deeply but not being caught by fishermen in open waters beyond the coast.[**] On the other hand, the red shrimp (Plesiopenaeus *edwardsianus*) appears to complete its entire life cycle at depths down to 2,500 feet and is not found in the estuary at any stage.[***]

Role of Estuaries in Shrimp Development

While the complete role of the estuary in shrimp development is still not thoroughly understood, the estuary appears to fulfill two primary functions: (1) provision of adequate nourishment during a period of rapid physical growth and (2) protection from predators. A large proportion of the shrimp's diet appears to consist of small, invertebrate animals, such as polychaete worms, mollusk larva, and small crustaceans, as well as fish larvae and nematodes. Since mud appears to be a significant proportion of the material found in the alimentary canal, it is assumed that muds are sought for the foraminifera, dinoflagellates, and various bacteria or molds.

While shrimp is a primary food item for various estuarine animals, including the red drum (*Sciaenops ocellata*), spotted seatrout (*Cynoscion nebulosus*), snook (*Centroponus undecimalis*), and the gray snapper (*Lutjanus griseus*), the estuary undoubtedly provides more vegetation and debris for protection than can be found in open waters. Furthermore, sufficient alternative foods exist in the estuaries for these fish so that some of the pressure can be removed from the shrimp.

Compatibility of Commercial Shrimp Industry and Estuarine Change

The future viability of the commercial shrimp industry undoubtedly will be influenced by two factors: (1) the impact that a changing estuarine environment has upon the existing stocks of commercial shrimp and (2) the ability of the shrimp fishermen to respond with appropriate new techniques or technological innovations. Estuarine change can take numerous forms, but most of the changes appear to bode unfavorably for maintaining present stocks of brown, white, and pink shrimp. In its most drastic aspect, change means that estuarine areas are completely removed from access by juvenile shrimp. While some specimens of juvenile pink shrimp have been found outside estuaries, it is currently assumed that none of the major commercial species would continue to exist in commercial quantities if estuaries were unavailable for development.* Thus, filling or diking of estuarine areas can be considered to reduce commercial shrimp stocks in some direct relationship to the estuarine area and volume removed.

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[*] Percy Viosca, Jr., "Effect of the Bonnet Carre Spillway on Fisheries", Louisiana Conserv. Rev., *6* (4), 51-53 (1938).

[**] Joseph H. Kutkuhn, "Gulf of Mexico Commercial Shrimp Populations--Trends and Characteristics, 1956-59", U.S. Fish and Wildlife Service, Fisheries Bulletin, *62*, 333-402 (1962).

[***] Stewart Springer and Harvey R. Bullis, Jr., "Collections by the *Oregon* in the Gulf of Mexico", U.S. Fish and Wildlife Service, Special Scientific Report, Fisheries, No. 196 (1956).

More difficult to evaluate are estuarine changes caused by estuarine or river modifications, including dams and navigational channels. In most cases, these modifications will alter the estuarine conditions, such as salinity, and thus will cause a deterioration in vegetation which will adversely affect shrimp stocks.** In a few cases, changes - particularly navigational channels - can theoretically improve estuarine conditions by providing access for shrimp to previously inaccessible marshes, by providing deep-water escape routes in case of sudden temperature drops or changes in salinity, and by stirring nutrients entrapped in sediments. On the other hand, these modifications are often accompanied by spoil banks and other negative changes in estuarine conditions, and the positive effects are more than counterbalanced. At this point in ecological sciences, estuarine modifications have to be evaluated on a case-by-case basis.

The effects of pollution similarly depend upon the particular situation. Small quantities of domestic sewage which do not deplete the oxygen content of the water significantly can provide nutrients which presumably improve the bearing capacity of the habitat. On the other hand, certain industrial-type wastes - such as insecticides - have been shown to have disastrous impacts. When a laboratory population of brown shrimp (*P. aztecus*) were fed a diet of DDT-contaminated oyster meats with a total DDT residue of approximately 2 ppm, half died within 2 weeks.*** Since DDT residues in shrimp or other crustaceans caught in estuaries are usually negligible or absent, it

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*T.J. Costello and Donald M. Allen, "Migrations and Geographic Distribution of Pink Shrimp (*Penaeus duorarum*) of the Tortugas and Sanibel Grounds, Florida", U.S. Fish and Wildlife Service, Fisheries Bulletin, *65* (2), 449-460 (1966).
Idyll, et al., Ibid., p 87.

**Gordon Gunter, "Some Relationships of Estuaries to the Fisheries of the Gulf of Mexico", Lauff (Ed.), Ibid., pp 621-623.
Charles Chapman, "Channelization and Spoiling in Gulf Coast and South Atlantic Estuaries", *Proceedings of the Marsh and Estuary Management Symposium* (July, 1967), pp 93-106.
A.R. Marshall, "Dredging and Filling", Ibid., pp 107-113.

***Philip A. Butler, "Fixation of DDT in Estuaries", *Transactions of the Thirty-First North American Wildlife and Natural Resources Conference* (March, 1966), p 189.

is generally assumed that this type of estuarine fauna is normally killed by concentrations less than can be identified and measured with existing technology.* While some resistance to pesticides is now being reported for some freshwater fish species, there is yet no evidence that such a resistance can be built up in crustaceans without a thorough disruption of their population distribution and densities.†

Thermal pollution is a relatively new phenomenon in the estuaries frequented by shrimp. However, there is no reason to believe that slight rises in water temperatures in the immediate vicinity of plant outflows would adversely affect shrimp stocks since they are relatively mobile. On the other hand, severe cold waves have been known to cause high mortalities among juvenile shrimp, and an area of artifically heater water could provide a sanctuary for some shrimp during these exceptionally cold periods.

Dredging and other activities which tend to create sudden shifts in silt deposition have to be evaluated on the basis of experiments that indicate that each shrimp species has an affinity for certain types of substrate. Brown and white shrimp prefer softer bottoms with sandy mud, muddy sand, or loose peat, while pink shrimp tend to select harder bottoms of mixed shell and sand or of low organic content.**

Several possible though difficult responses appear to exist for United States commercial fishermen if deteriorating estuarine conditions restrict the stocks of shrimp species now being harvested. For instance, part of the burden of harvesting can be shifted to a new, less estuarine-dependent species, particularly the royal red shrimp (Hymenopenaeus robustus) or aquaculture or farming of shrimp can be developed. Because of the elusive and deep-running nature of the royal red shrimp, technological improvements in both location detection and the quality of equipment would have to occur if the former option were to be followed. Furthermore, certain market resistance to the acceptability of red shrimp would have to be overcome, a less serious problem with the advent of breaded shrimp which shields the skin color. On the other hand, past shrimp-culture efforts in this country have not been promising, despite some limited progress in Japan and the traditional, pond-culture methods of South America and parts of the Indo-Pacific. Research activities are continuing, however.***

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*Philip A. Butler, "Pesticides in the Estuary", Proceedings of the Marsh and Estuary Management Symposium (July 19-20, 1967), p 123.

†Kutkuhn, "The Role of Estuaries in the Development and Perpetuation of Commercial Shrimp Resources", p 27.

Denzel E. Ferguson, "The Ecological Consequences of Pesticide Resistance in Fishes", Transactions of the Thirty-Second North American Wildlife and Natural Resources Conference (March, 1967), pp 103-107.

**Austin B. Williams, "Substrate as a Factor in Shrimp Distribution", Limnology and Oceanography, 3, 283-290 (1958).

Durbin C. Tabb, "Biological Fresh Water Requirements of South Florida Estuaries", unpublished manuscript of the Institute of Marine Sciences, University of Miami (1967).

***G. Robert Lunz, "Farming the Salt Marshes", Proceedings of the Marsh and Estuary Management Symposium (July, 1967), pp 172-177.

H.E. Crowther, "BDF Role in Farming of the Sea", 1967 Proceedings of the National Shellfisheries Association (June, 1968) Vol. 58, pp 16-18.

Victor L. Loosanoff, "Mariculture... Its Recent Development and Its Future", Agricultural Engineer, 46 (2), 73, 93-97 (February, 1965).

ESTUARINE DEPENDENCE OF MENHADEN

Commercial menhaden resources in the United States consist primarily of four species: the Atlantic menhaden (Brevoortia tyrannus), the Gulf menhaden (B. patronus) the yellowfin menhaden (B. smithi), and the finescale menhaden (B. gunteri). As in the case of shrimp, spawning for all species occurs at sea along the continental shelf, and the eggs hatch in the ocean after about 2 days. Larvae move into the estuaries and quickly penetrate as far as 25 to 35 miles into freshwater rivers.* A transformation of its physical characteristics accompanies the entrance into the estuaries as the organism shifts from being a selective, particulate feeder to being a nonselective, filter-feeding omnivore. Within the estuaries, the juvenile menhaden can tolerate wide variations in both salinity and temperature. Some specimens have survived in freshwater reservoirs (though they did not reproduce), while other juvenile specimens have developed into the adult stage at ocean salinities in a laboratory tank.**

Role of the Estuary in Menhaden Development

Food appears to be the primary biological factor in the menhaden's dependence upon the estuary. Before metamorphosis in feeding mechanisms, zooplankton forms the principal food. After metamorphosis, food becomes primarily dinoflagellates diatoms, small zooplankton, and virtually any other natural plankton that the menhaden can strain from the water. They are even known to graze directly on dense floating scum, such as Anabaena in Lake Pontchartrain near New Orleans. The menhaden population of an estuary seems to be determined both by the number of larvae entering the waters and the parameters of the estuary in terms of food, oxygen, competition, and predators. Because they are primary consumers, feeding directly upon the natural vegetation, menhaden represent the base of the food chain for many predators, such as the bluefish (Pomatomus saltatrix), striped bass (Roccus saxatilis), bluefin tuna (Thunnus thynnus), and sharks. In terms of biomass, menhaden are probably second in the United States only to the bay anchovy (Anchoa mitchilli).

Compatibility of the Menhaden Industry and Estuarine Change

As with the shrimp industry, the production of menhaden appears to be directly dependent upon the existence of estuarine waters with sufficient quality standards. Removal of estuarine areas by either diking or filling will presumably have an impact roughly proportional to the area and volume removed, the exact quantity depending upon the parameters of the particular estuary. Polluted waters, however, raise particularly difficult questions with menhaden because of their proclivity toward parasites and disease. Serious parasitic infections noted have included copepods on the body surface and gills, isopods in the buccal cavity, monogenetic trematodes on the gills, digenetic trematodes in the intestine, and sporozoans in the testes. While not usually fatal in themselves, these parasites can weaken a fish's resistance to other environmental threats as well as reduce fertility.* These infections are generally associated with the estuarine phase of the life cycle, either being caused by factors existing during that period or becoming obvious by then. The exact role - if any - of pollution in promoting these infections is unknown, but the intense flow of nutrients associated with most domestic and industrial sewage can be seen to, at best, create more favorable conditions for propagation of parasitic infections.

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*John W. Reintjes and Anthony L. Pacheco, "The Relation of Menhaden to Estuaries", A Symposium on Estuarine Fisheries, Special Publication No. 3, American Fisheries Society, Washington, D.C. (1966), pp 50-58.

**F.C. June and J.L. Chamberlin, "The Role of the Estuary in the Life History and Biology of Atlantic Menhaden", Proceedings of the Gulf Caribbean Fisheries Institute, Eleventh Annual Session (1958), pp 41-45.

ESTUARINE DEPENDENCE OF OYSTERS**

Virtually the entire commercial oyster fishery is based on one domestic species, the Virginia oyster (Crassostrea virginica). From about 1890 to 1930, a significant industry was developed on the Pacific Coast using a native Pacific species, the Olympia oyster (Ostrea lurida). However, environmental change, particularly the presence of toxic liquid waste from paper mills, proved fatal to the larvae and the fishery collapsed. A partial revival was achieved using imported seeds of the Japanese oyster, Crassostrea gigas, which is slightly more tolerant to paper mill chemicals. Yet only 5.9 million pounds of oyster meat were harvested on the Pacific Coast in 1967, compared with 51.8 million pounds of the Virginia oyster on the East Coast, and the general trend of the Western oyster harvest has been sharply downward since 1959.***

The Virginia oyster has a range extending beyond the United States' borders into both Mexico and Canada, a spawning temperature of nearly 70 F being the limiting factor in northern waters. It tolerates salinities as low as 7 ppt in Chesapeake Bay and as high as 30 ppt, but the lower estuarine salinities are usually considered optimal for growth and defense from predators.**** In spawning, the eggs are cast directly into the water where they are fertilized, hatch, and the developing larvae remain free-swimming for approximately 9 to 25 days. Then as spats they settle to the bottom, weighted by their developing shells.

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*Reintjes and Pacheco, op. cit., p 56.

**While estuarine conditions are significant for salmon, the second most valuable estuarine-dependent species after shrimp, the current crisis in the supply of this anadromous fish appears more related to other factors, including gross disturbances of the natural conditions in major spawning streams, blockage of river systems by hydroelectric installations, and massive pressure from overfishing. The complexity of these factors are beyond the scope of this review. A brief summary of the difficulties can be found in McHugh, "Estuarine Nekton", pp 612-613.

***Lyles, op. cit., p 22.

****Gunter, op. cit., p 629.

If the larval oyster finds a suitable surface, it begins to cement itself and develop the calcium carbonate shell. Usually the small seed oysters are moved to growing beds after 6 to 9 months. In the Gulf states they reach market size, about 3 inches, in less than 3 years, but this growth may take as long as 5 years in the colder, more northern waters.

Role of the Estuary Development

As an organism, the Virginia oyster is thoroughly adapted to the estuarine ecosystem, appearing to find here the most appropriate food and substrate conditions. The primary food of the oyster consists of microscopic plants and animals, though decaying seaweeds can also contribute food value. The gills of the oyster act as both a pump and food collector, drawing water into the shells, sieving out the food, and expelling the strained water and wastes.

Compatibility of the Oyster Industry and Estuarine Change

The record of the oyster industry in the United States consists of a continuing series of disasters, usually associated with man-made changes in the estuaries. The Pacific Coast experience noted earlier has had variations in virtually every other prime oyster region of the country with (1) a form of pollution fatal to the oysters, (2) a level of pollution which has rendered the oyster unfit for consumption, (3) a loss through dredging and siltation of adequate clutch material for the spats, (4) disease, (5) predators, or (6) some combination of these and unidentified causes. During the 19th Century, Raritan Bay and Jamaica Bay in the New York area were developed as major centers for oyster culture, with the Hudson beds providing seed.* As pollution drove oyster culture from these areas, the Connecticut shore of Long Island Sound became a primary source of seed oysters, with the growing beds in Rhode Island, Massachusetts, Connecticut, and New York.

This industry was abruptly shattered by the hurricane of 1950, when oyster beds and setting grounds with a total value extending into the millions of dollars were lost. Efforts to reestablish the industry in the same areas failed, presumably because a combination of estuarine change, such as caused by dredging and filling, and the increasing presence of industrial and domestic pollution could no longer be tolerated by the oysters. Commercial oyster operations have completely vanished in Rhode Island, almost ended in Massachusetts, and drastically declined in Connecticut and New York. Even the Chesapeake Bay beds have been reduced.

A spectacular case of estuarine pollution occurred in Great South Bay on Long Island in 1950. Establishment of duck farms on the Bay's watershed led to a rapid increase in phytoplankton density and to a complete change in the type of producer organisms present. The normal mixture of diatoms, green flagellates, and dinoflagellates was almost completely replaced by small, little-known flagellates known by the genera of Nannochloris and Stichococcus.* The famous "blue-point" oysters, which had flourished in the Bay under the cultivation of descendants from the original Dutch families, gradually became unfit for market and then died. Disection showed that the oysters were unable to digest the green flagellates. In experiments, it was shown that the green flagellates by-passed the normal nitrogen cycle which requires organic material to be reduced by nitrates, instead using the nitrogen directly in the form of urea, uric acid, and ammonia.** Thus, the oysters were starving in the midst of the flourishing flagellates, which were being fertilized by phosphates from the duck ponds. After about 5 successive years during which the industry was abandoned in the Bay, inlets on the east end were opened to the sea and the condition seemed corrected with the increased salinity. While the oyster industry was then resumed, the scale was considerably diminished from that of earlier years.

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*David H. Wallace, "Oysters in the Estuarine Environment", A Symposium on Estuarine Fisheries, Special Publication No. 3, American Fisheries Society, Washington, D.C. (1966).

In the past two decades, the increased level of chemical pollutants, such as pesticides, in some of the estuarine environments has been charged with decreasing the vigor of and, in some cases, possibly eliminating oysters.*** Oysters exposed to concentrations as low as 0.01 ppm of polychlorinated hydrocarbon insecticides, or polychlors, quickly shows physiological irritation by changes in shell movements. Contrasted with oysters in pesticide-free water, their shell deposition or growth has been shown to be inhibited by approximately 60 percent after shell rims have been ground smooth. Furthermore, oysters exposed to concentrations of DDT as low as 0.0001 ppm can store this chemical in tissues to a concentration of 7 ppm, a biological magnification of 70,000 times. If the level of DDT is increased from 0.0001 ppm to 1.0 ppm, oyster growth decreases logarithmically from 20 to 90 percent. However, the oysters are also able to flush the pesticide from their bodies at rates dependent upon the initial concentration, and growth rates can resume to normal after as short a period as 10 days in uncontaminated water while body residues are still greater than 100 ppm. While the implications for mortality are still not clear, oyster eggs have concentrations as high as 25 ppm after the adults have been exposed to 1.0 ppm of DDT for 12 days, and some experiments have shown 100 percent mortality for oyster larvae within 6 days with an exposure on only 1.0 ppm DDT.**** Lake-trout eggs with similar concentrations have been shown to be almost completely sterile.† Ironically, the oyster drill (Thais haemastoma) appears to suffer no ill effects and does not built up significant DDT residues when fed live oysters containing about 50 ppm of DDT.* The Bureau of Commercial Fisheries is now monitoring the pesticide levels in estuaries at various points in the country.

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*John H. Ryther, "The Ecology of Phytoplankton Blooms in Moriches Bay and Great South Bay, Long Island, New York", Biological Bulletin, 106, 108-209 (1954).

**Eugene P. Odum, Fundamentals of Ecology, Saunders, London (1959), p 97.

***Philip A. Butler, "The Problem of Pesticides in Estuaries", A Symposium on Estuarine Fisheries, Special Publication No. 3, American Fisheries Society, Washington, D.C. (1966).

****Harry C. Davis, "Effects of Some Pesticides on Eggs and Larvae of Oysters (Crassoscrea virginica) and Clams (Venus mercenaria)", Commercial Fisheries Review, 23 (12), 8-23 (1961).

†Philip A. Butler, "Pesticides in the Estuary", Proceedings of the Marsh and Estuary Management Symposium (July, 1967), p 123.

Another aspect of the pollution problem, particularly in southern waters, is for the oyster beds to be closed by public health authorities because of high coliform counts in the vicinity. In 1967, for instance, all beds in Biloxi Bay, Mississippi, were closed to harvesting, and about 3,000 acres of beds in Louisiana are estimated to be closed.** But in many cases, including beds in parts of Biloxi Bay, the oysters are exceptionally healthy in appearance, presumably because of the high nutritional value of the water's phytoplankton. Oysters in beds subject to pollution are even able to tolerate short periods of anaerobic conditions. As described previously, though, this tolerance does not normally extend to many of the industrial chemicals.

Besides, a need for chemically pure waters, oysters are sensitive to adverse clutch, or substrate, conditions for the settling spats. Increased mining of oyster-shell banks for the lime content has removed the traditional and convenient clutch material, while marine engineering operations, such as dredging and filling, have either altered estuarine currents or created excessive silt conditions that have buried the clutch material.

For future development of the oyster industry, the general trend appears to be towards highly controlled water conditions in ponds and other technological means of "farming" the fishery. Hatcheries are being established to produce seed, and floats are being used to suspend oysters in the water column, thus utilizing the total volume of suitable water more efficiently and protecting the oysters from bottom-dwelling predators, such as the drills and starfishes. Also, depuration plants are being devised to allow oysters from polluted waters to purge themselves of any pathogenic organisms. In the future, the water environment may be further controlled by harnessing the waste heat now discharged by power-generation plants and similar industries as thermal pollution.

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*Philip A. Butler, "Fixation of DDT in Estuaries", Transactions of the Thirty-First North American Wildlife and Natural Resources Conference (March, 1966), p 189.

**T. A. Wastler, "Municipal and Industrial Wastes in the Estuaries of the South Atlantic and Gulf Coasts", Proceedings of the Marsh and Estuary Management Symposium (July, 1967), p 115.

For summaries of the state of the art in tidal pollution and implications in shellfish culture, see:

Gerald A. Strobel, "Coliform-Fecal Coliform Bacteria in Tidal Waters", Proceedings of the American Society of Civil Engineers, No. 6068 (August, 1968), pp 641-656.

T.G. Metcalf and W.C. Stiles, "Viral Pollution of Shellfish in Estuary Waters", Proceedings of the American Society of Civil Engineers, No. 6063 (August, 1968), pp 595-609.

Estuarine Dependence of Other Species

Each of the other estuarine-dependent species represents a special ecological situation. The striped bass (Roccus saxatilis), for instance, has shown remarkable adaptive capabilities to completely freshwater environments and to different geographical circumstances.* The greater biomass resulting from mild domestic pollution may have enhanced the crop of adult bass.** However, the fish remains sensitive to serious pollution conditions, and it is particularly dependent upon stringent spawning conditions, especially an unimpeded freshwater current with certain velocity constraints. Thus, river barriers can destroy the prerequisite conditions for propagation.

By contrast, the spotted seatrout (Cynoscion nebulosus) is consistently an estuarine fish, preferring the brackish, nontidal bays such as can be found along the Gulf of Mexico.*** These fish can spend their entire life cycle in the estuary and possess an exceptional tolerance to salinity variations. Despite this adaptability, however, estuarine destruction or creation of barriers between shallow and deep waters will destroy the necessary characteristics of their natural habitat.

Several incompatible trends appear to be occurring between the preferences of the United States' consumers and physical realities. On one hand, consumption of certain fishery products - such as shrimp and industrial fish derivatives - is increasing. The existing United States catch has been augmented by imports, but this supplemental supply is unreliable.

On the other hand, the fish species in rising demand - including shrimp, crabs, and most domestic industrial fish - are predominantly estuarine-dependent. Yet the estuarine habitats are being altered in many ways that will destroy a significant proportion of these fisheries. This trend is particularly marked in the Gulf region which, until recently, was spared intensive industrialization.

Some loss in available fish stocks seems inevitable. By judicious control of estuarine changes, the loss can be minimized. Some compensation for destruction of estuarine habitats can possibly be made by cultivation of certain species in specially controlled areas. But, with existing techniques, this approach is ineffective for other species. And the scale and nature of the natural estuarine zones in the United States makes any reasonable substitution by aquaculture appear both technically and economically unfeasible. Thus, a harsh choice appears inevitable: greater estuarine management or less commercial fishery stocks.

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*Gerald B. Talbot, "Estuarine Environmental Requirements and Limiting Factors for Striped Bass", A Symposium on Estuarine Fisheries, Special Publication No. 3, American Fisheries Society, Washington, D.C. (1966).

**R.J. Mansueti, "Effects of Civilization on Striped Bass and Other Estuarine Biota in Chesapeak Bay and Tributaries", Proceedings of the Gulf Caribbean Fisheries Institute, Fourteenth Annual Session (1961), pp 110-136.

***Durbin C. Tabb, "The Estuary as a Habitat for Spotted Seatrout (Cynoscion nebulosus)", A Symposium on Estuarine Fisheries, Special Publication No. 3, American Fisheries Society, Washington, D.C. (1966), pp 59-67.

APPENDIX C

ECONOMIC AND SOCIAL VALUE OF ESTUARINE WILDLIFE

Granville H. Sewell

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APPENDIX C

ECONOMIC AND SOCIAL VALUE OF ESTUARINE WILDLIFE

by

Granville H. Sewell

Excluding the fishery resources, estuarine wildlife can be classified into four categories with differing economic and social significance for the United States population: (1) fur-bearing mammals, (2) game waterfowl, (3) "exotic" shore birds, and (4) the common wildlife that can tolerate human presence. Each category represents a drastically different relationship to the human community; and within the individual categories wide variations can be found in the degree of dependence upon estuarine conditions.

FUR PRODUCTION

The clearest and simplest case is represented by the fur-bearing mammals. They are commercially trapped, and the sale of their pelts offers a clear indication of economic value. In the 1965-1966 trapping season, for instance, trappers in the coastal marshes of the Gulf and Atlantic states sold about $5 million in fur and possibly another $1 million in meat, primarily nutria. * Louisiana was primary producer, with about 1,257,400 nutria, 324,200 muskrat, 78,300 raccoons, 28,200 mink, and 3,600 otter for a total value of approximately $4,600,000. Roughly $4 million of this can be attributed to the 3.5 million acres of coastal marsh. This annual value of fur production is highly unstable, and the variation from one year to the next can be as great as 50 percent.

The primary fur bearers involved are the nutria (Myocastor coypus) in the South Atlantic and Gulf states, the common eastern muskrat (Ondatra zebethicus) in New Jersey, the Virginia muskrat (Ondatra z. macrondon) in the central Atlantic states, and the Louisiana muskrat (Ondatra z. rivalicius) in Alabama, Mississippi, Louisana, and Texas. Secondary in importance are the raccoon (Procyon spp.), mink (Mustela spp.),

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* Ted O'Neil, "Comparative Takes of Fur Animals in Louisiana", Louisiana Department of Wildlife and Fisheries (1966).

and otter (Lutra spp.). Foxes (Vulpes and Urocyon), weasels (Mustela spp.), opossum (Didelphis virginiana), and bobcats (Lynx spp.) are not sought for their fur but may occasionally be trapped. *

For economic levels of fur production, the marshes must be manages specifically for the fur bearers. For practical purposes, this means control of undesirable plants, prevention of excessive populations, and, in some cases, control of predators. The primary food plant is the threesquare (Scirpus olneyi) and, to a lesser extent, the cattails (Typha supp.). Since these are subclimax plants, they can be superseded by invading needlerush (Juncus roemerianus), cordgrass (Spartina patens), sawgrass (Cladium jamaicense), and other undesirable plants. Hence, the marshes are burned annually, usually in the fall, and are subsequently flooded to eradicate the pest plants and enhance growth of the threesquare.

Saline waters will burn the marsh vegetation, particularly the threesquare and cattails, and one of the prime objectives of using dikes or other water-control devices is to help minimize the intrusion of saltwater into the fresh or brackish water of these marshes. Thus, the marshes managed for fur production are not normally available for most typical aquatic estuarine life, especially shrimp and the fish that use the estuaries as a nursery.

Threats to Fur Production

Hurricanes and man-made intrusions upon the fur-producing marshes have represented the most serious threats to the fur-bearing animals and their habitat. Between 1933 and 1936, 500,000 acres of marsh were reclaimed in New Jersey, Delaware, and Maryland. ** This project was promoted by the U.S. Public Health Service and conducted by the Works Project Administration to reduce the mosquito-breeding areas in the eastern United States. Some of this marshes have reverted to their original state, but ditching to control mosquitoes has continued to a lesser extent in virtually all coastal states. Marsh empoundments and fish stocking have been shown to accomplish the same objective. At the same time, empoundments provide excellent habitats for muskrat and waterfowl while drainage creates a near wasteland. ***

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*Kenneth A. Wilson, "Fur Production on Southeastern Coastal Marshes", Proceedings of the Marsh and Estuary Management Symposium (July, 1967), p 150.

**C. Cottam, W. S. Bourn F. C. Bishopp, L. L. Williams, and W. Vogt, "What's Wrong With Mosquito Control ?', Transactions of the North American Wildlife Conference, Vol. 3 (1938), pp. 81-98.

***Otto Florschutz, Quarterly Progress Report, Federal Aid in Wildlife Restoration, North Carolina Wildlife Resources Commission, Raleigh, N.C., Vol. 18 (1965), pp. 8-26.

Navigation and similar construction projects have frequently had serious adverse effects. One of the most severe in terms of fur production could be the proposed channel through the Atchafalaya Basin by the Corps of Army Engineers. This is considered to pose a direct threat to about 1,300 square miles of exceptionally productive marsh and adjacent wildlife habitat. On a gradually rising scale, highway construction, canal systems, dredging and filling, flood-control works, and the other encroachments of physical development and urbanization are slowly removing significant areas of marsh. At the same time, industrial activity, particularly in the Delaware and New Jersey regions, have devastated many square miles of marsh with pollution. Intensive applications of pesticides are also believed to significantly effect some areas.

While man's impact may be the most persistent and significant over an extended time, no changes introduced by man can rival hurricanes for sheer, sudden destruction on a massive scale. Dikes and levies are breached, and ditches are filled. Marsh areas that have been overgrazed are completely gouged out, and the surging storm tides drown thousands of animals. Vegetation that remains is scalded by the saltwater. The drastic decline in muskrat harvest since World War II appears to have been precipitated by the 1947 hurricane. This destruction was compounded by a series of other hurricanes during the 1950's, and Betsy in 1965 succeeded in destroying some of the rebuilt control works.

The effect of predators upon fur production is rarely serious. In the several recorded instances where predators have been held responsible for significant declines in production, the most frequent culprit appears to have been the raccoon which destroys the young in the nestling stage. *

Economic Significance of Fur Production

On a national scale, the harvesting of pelts from marsh animals is a miniscule industry. Even in local terms, trapping is normally restricted to several months (90 days in Louisiana) of the year and usually supplements income earned from other occupations. Furthermore, the industry is susceptible to domestication, fur farming being the primary source of mink pelts. Because of the managed nature of the fur-production marshes and their weak ecological relationship with the estuaries, fur production does not appear to be a major victim of man-made estuarine change.

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* John J. Lynch "Values of the South Atlantic and Gulf Coast Marshes and Estuaries to Waterfowl," Proceedings of the Marsh and Estuary Management Symposium (July, 1967), pp 51-63.

WATERFOWL

The United States waterfowl - primarily ducks, geese, and swan - represent both an aesthetic and a recreation industry resource. The relationship, however, between these waterfowl and the estuarine zone is both complex and incompletely understood. * The primary sport species, such as the mallards and canvasbacks, have shown a keen ability in adapting to man-made changes in their environment, particularly those changes not related to the nesting sites. In some cases, even nesting has been enhanced by the construction of roads, drainage canals, and other works that stabilize water levels and thus provide flood-proof nesting sties and drought-proof rearing ponds. ** Furthermore, most species do not appear particularly dependent on any aspect of the estuarine zone, as they are able to use freshwater marshes, lakes, and ponds with equal ease. The primary problem appears to be the moral issue of threatening the existence of the less adaptable species. A brief review of the primary waterfowl groups helps to place the role of the estuarine zone in perspective.

The Larger Waterfowl

The whistling swans are one of the most spectacular estuarine waterfowl, and are frequently found in the lower reaches of major Atlantic estuaries. While its habits are not completely understood, the adaptability of this species in captivity has demonstrated that it can survive environmental changes. Considerably more is known about the geese populations, which present several sharp contrast to the waterfowl. For example, the lesser snow geese have abandoned the coastal marshes in favor of rice fields and upland cattle pastures, and appear to be thriving. The white fronted geese have made a similarly successful change in habitat. The Canada geese have demonstrated even more adaptability, with many remaining for the entire winter in the freshwater bodies of the Midwest, particularly in Missouri and Illinois. While large numbers of Canada geese can still be found in coastal marshes, it is assumed that these birds could adapt quickly to any changes in their aquatic environment. By contrast, the brant appears to be stubbornly dependent upon ellgrass (Zostera marina), and the disappearance of this coastal vegetation has apparently resulted in drastic decreases of brant. *** Similarly, the greater snow geese have continued to frequent Atlantic-coast marshes and have not increased in numbers during recent years.

The Dabbling Ducks

While large numbers of mallards and pintails can be found congregating in coastal marshes, this marsh habitat is generally considered to be only a resting area. Most feeding occurs in coastal rice fields and other agricultural areas. In recent years, many mallards have tended to remain the entire winter in Midwestern corn and wheat zones, and the estuarine waters do not appear to be a critical factor in their environment. Nor does this appear to be the case for the pintails, which are considerably more mobile than the mallards. The black ducks, the dominant duck of the Atlantic flyway, exhibit a determined preference for natural marshes and environments undisturbed by man. Yet they are also adaptable, willing to accept inland ponds and lakes as well as major rivers. A similar lack of environmental commitment is shown by the American widgeons, the gadwalls, shovelers, green-wing teal, bule-wing teal, and wood ducks.

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* John J. Lynch "Values of the South Atlantic and Gulf Coast Marshes and Estuaries to Waterfowl," Proceedings of the Marsh and Estuary Management Symposium (July, 1967), pp 51-63.

** Ibid., p. 61.

***C. Cottam, J. J. Lynch, and A. L. Nelson, "Food Habits and Management of the Brant", Journal of Wildlife Management, 8 (1), 35-56 (1944).

Diving Ducks

Unlike the dabbling ducks, dividn ducks do not appear to have developed a strong dependence upon agricultural lands for their continued existence. Rather, they seem to display a general ambivalence toward specific types of environments. Scaups, redheads, and canvasbacks can be found during winters in both saltwater bays and sounds as well as freshwater ponds and reservoirs. Hooded mergansers and buffleheads show a slight preference for coastal lagoons, while larger mergansers, goldeneyes, and old squaws (known as "sea ducks") winter primarily in the deeper saltwater, though they will frequently gather within coastal lagoons. Eiders and scoters are even more dependent upon the deeper saltwater. Their opposites in the freshwater environment are the ringnecks and ruddies, which winter in ponds and small lakes, though they may be found occasionally in the freshwater marsh ponds of the coast. Ruddies have been reported to feed extensively on midge larve (Chironomidae) in turbid, heavily polluted zones of Chesapeake Bay, suggesting that ducks are not repulsed by organically polluted waters. * The long-term effects of this feeding environment in terms of disease are still unknown, although domesticated ducks have been reared for centuries in polluted farm ponds. A more significant problem may be the dependence of many sea ducks upon small crustaceans, fish, and insects that are estuarine-dependent.

In summary, while waterfowl are frequently observed in the estuarine areas, their numbers do not generally appear dependent upon specific estuarine conditions. Some exceptions, such as the American brant, may exist, but even here the research has been inadequate to determine the role of incomplete censuses or poor nesting conditions in the declining numbers.

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* Lynch, op. cit., p 59.

THE "EXOTIC" SHORE AND SEA BIRDS

Rarely serving a direct economic function except as a component of the natural ecosystem, the more spectacular shore and sea birds nevertheless perform a particularly significant aesthetic role among our national fauna. Only slightly more dependent upon estuarine conditions than the more mobile waterfowl, these birds have demonstrated a considerably greater sensitivity to the overall encroachment of man. The sage of the whooping crane is well known and documented, and the trails of several other groups, such as the egrets, have received periodic publicity. However, the current assumption of many naturalists is that few of the species are in actual danger of extinction, and respectable numbers of most species can be maintained by wise planning in the estuarine zones. *

Pelicans, Cormorants, Eagles, and Ospreys

The larger fish eaters of the United States coast appear among the most threatened of the bird life by changing environmental conditions, especially in the estuaries. The Department of Interior has officially listed the southern subspecies of the bald eagle as an endangered species. ** The brown pelican has already disappeared from the Gulf coasts of Alabama, Mississippi, Louisiana, and Texas, where it was a common sight prior to 1960. Since this disappearance coincided with the heavy fish kills of 1960-1964 in the lower Mississippi River which were caused by excessive residues of pesticides, especially endrin, it appeared that the dying pelicans observed during that period had accumulated lethal dosages. *** The assumption was not verified. Another theory used to explain the lack of any resurgence by the species was the destruction of black mangrove (Avicennia nitica) nesting grounds by the severe cold.

Except for about 50 pairs of bald eagles nesting in the Everglades National Park, the population has suffered a sharp decline in the past three decades. In the Chesapeake Bay area, nesting success has dropped from 50 to about 15 percent. **** About 70 percent of the Southern subspecies nest in either marsh or estuarine areas, and the general assumption is that they are also suffering from the dual pressures of pesticide residues in the estuaries and more latent inroads by man, including vandalism.

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* Alexander Sprut, IV. "Values of the South Atlantic and Gulf Coast Marshes and Estuaries to Birds Other Than Waterfowl", Proceedings of the Marsh and Estuary Management Symposium (July, 1967), pp 64-72.

** Bureau of Sport Fisheries and Wildlife, Rate and Endangered Fish and Wildlife of the United States, Resources Publication 34, Washington, D. C. (1966).

*** Donald I. Mount and George J. Putnicki, "Summary Report of the 1963 Mississippi Fish Kill." Transactions of the Thirty-First North American Wildlife and Natural Resources Conference (1966), pp 177-184.

**** Sprunt, op. cit., p 68.

Similar declines have been occuring in the populations of ospreys, though geographically the changes have not coincided with those of the eagles. Very little research has been performed on the particular problems of the ospreys, and a reasonable understanding of the relationships between the osprey population and the environment has not been achieved. Both birds depend upon the fish population of the estuarine areas, including mullet and catfish.

Significant changes in the numbers of white pelicans have not been noted, but this species is distributed on both the Atlantic and Pacific coasts extending into Mexico. Unlike the brown pelican, it is usually only a seasonal resident on the Atlantic and Gulf estuaries, but it is presumably equally dependent upon estuarine fish life and ecological conditions.

The cormorants have exceptionally wide ranges of habitats. One subspecies nests in saltwater areas of Florida, but most of this family can be found breeding in Texas, Louisiana, and around freshwater, brackish, or saltwater environs throughout the southern United States and into Central America.

The Waders

The eighty species of waders, which include the egrets, storks, herons, ibis, and spoonbills, are predominantly residents of the southern United States, particularly Florida. These species are currently undergoing a crisis because of the drought conditions in the Everglades, and their numbers have declined drastically as a result. For some species, this represents a serious setback in their gradual recovery from near extinction at the hands of the plume hunters. About 1,800 great white heron in the salt flats and mangroves of southern Florida constitute the entire population of this species. Most of the other representatives, such as the common egret, snowy egret, great blue heron, Louisiana heron, and little blue heron, are more widely distributed and are generally more flexible in their habitat requirements, accepting both saltwater and freshwater, though generally preferring one or the other. One exception is the reddish egret, which has failed to increase its decimated numbers since the plume trade was ended. It appears dependent upon saltwater environments, but its ecological requirements are not yet understood. The four species of ibis are also inadequately studied for management purposes, but the distribution is relatively wide, extending from the Carolinas to Texas, though their numbers are restricted. The roseate spoonbill is flexible in its salinity requirements and has been increasing in numbers in recent years.

Others

Numerous species of marsh birds, such as the rails and gallinules, are distributed throughout the marsh zones, but there is no evidence that they are estuarine-dependent. Shore birds such as the golden plover are a diverse and exceptionally mobile family and, while also not dependent upon the estuary per se, certain changes in the estuary such as concentrated pesticide pollution could cause large-scale mortality. Many of the gulls, such as the laughing gull, frequent the estuaries during the winter months. Some, such as the gull-billed heron, utilize offshore islands for nesting and have been displaced when these islands have been developed. As the marshes and underbrush of the estuaries are removed, still further families, such as the blackbirds, grackles, and seaside sparrows, will be affected.

Common Wildlife

For many of the major cities in the Unites States- such as New York, Boston, and San Francisco - the estuaries represent the most striking expanses of open space within the vista of the urban dweller. Municipal New York's boundaries, for instnace, encompass 320 square miles of land and 65 square miles of water. In every case, this open expanse also harbors innumerable forms of wildlife which are counted among a city's significant resources. Within the past two decades, urban dwellers have shown an increasing interest in nature studies and the myriad facets of their immediate natural environment. During the summer of 1960, the National Recreation Survey indicated that about 98 million activity-days had been occupied by nature walks. By the summer of 1965, the nature walks had increased to 117 million activity-days, a rise of 19 percent over a period of 5 years. * The National Wildlife Federation initiated the magazine, National Wildlife, in 1963 with a circulation of 60,000. By 1967, circulation stood at 250,000. Within 10 years, membership in The Wilderness Society rose from 9,000 to 36,000. Bird watching has become the subject of considerable public amusement but has also attracted dedicated devotees.

Many of the major cities have had published studies of their natural history, John Kieran's Natural History of New York City being perhaps the best known. ** The variety of estuarine wildlife that he describes is typical of the subjects sought by amateur urban naturalists. While not exactly a form of wildlife, seaweed appears along the shores in numerous forms, including the brown bladder wrack (Fucus vesiculosis), the green sea lettuce (Ulva lactuca), the brown henware (Alaria esculenta), red chenille weed (Dasya pendicillata), and purple carrageen (Chondrus crispus). If the water is sufficiently free of pollution, colonies of sponges can be found on the bottom with other forms of submarine life, including sea anemones, jellyfish, ribbon worms, and numerous crustaceans. The latter could include water fleas, copepods, barnacles, blue crabs, hermit crabs, calico crabs, fiddler crabs, grass shrimp, and sand shrimp. As the tides recede, numerous shells can be found, including those of the horseshoe crabs, whelks, snails, periwinkles, and possibly 40 to 50 species of oysters, clams, scallops, mussels, and other bivalves. Starfish, sea urchins, and sea cucumbers are among the most picturesque members of the estuary life. Thirty-one species of amphibians, including salamanders, frogs, and toads have been recorded in New York State, most of them freshwater species but a few being found in the brackish areas of the estuary. Occasionally, the saddleback or harp seal (Phoca groenlandica) and the harbor seal (Phoca vitulina) can be seen during the winter in the Lower Bay. Vegetation bordering the tidal flats can harbor raccoons, mink, weasels, skunks, and similar common mammals.

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* Stuart T. Davey, "The Role of Wildlife in an Urban Environment", Transactions of the Thirty-Second North American Wildlife and Natural Resources Conferences (March, 1967), pp 50-60.
Also see: Forest W. Sterns, "Wildlife Habitat in Urban and Suburban Environment", pp 61-69.
Robert H. Twiss, "Wildlife in the Metropolitan Landscape", ibid., pp 69-74.

** John Kieran, Natural History of New York City, Houghton Mifflin, Boston (1959).

The richest variety of wildlife for a city located in an estuary is the diversity of waterfowl, shore birds, and sea birds. On a tonnage basis, Kieran estimates that the approximately 50,000 heron gulls typically found within New York City during January would outweigh all the starlings and, possibly, the pigeons, too. Other sea birds include the ring-billed gull, the great black-backed gull, the laughing gull, the Bonaparte's gull, the glaucous gull, the Iceland gull, the black-legged kittiwake, the common tern, the roseate tern, forster's tern, the Arctic tern, the least tern, the black tern, the black skimmers, and the gannet. In the early 1960's, the Department of Parks established the Jamaica Bay Wildlife Refuge to provide nesting grounds for sea birds as well as various marsh birds. Even a novice bird watcher can identify the common loon, the red-throated loon, and the horned grebe in the offshore waters. Canada geese occasionally nest within the city limits, and the brant has been returning to New York City in increasing numbers due to the resurgence of eelgrass growth in the estuary. Only the black duck can be found during the entire year, but numerous species, including the American widgeon, the mallard, the gadwall, the pintail, the blue-winged teal, the green-winged teal, the shoveler, the greater scaup, the lesser scaup, the redhead, the canvasback, the goldeneye, the bufflehead, and the old squaw, can be found in Jamaica Bay during the fall, winter and spring. This list does not include the waders, shore birds, and marsh birds. Nor does it include the species of fish that the fishermen of the harbor bring from the water.

CONCLUSION

As these discussions indicate, the principal value of estuarine wildlife lies within the social realm, and is not readily convertible into monetary terms. It is within the social province that the significant increases in value will appear as populations increase and natural areas become more remote from urban centers. Concurrently, the monetary value of estuarine uses conflicting with wildlife will rise, intensifying an already-existing conflict. But the nature of the wildlife generally appears sufficiently adaptable that some compromise and considerable planning can preserve both the major wildlife populations and serve the critical needs of the United States society.

APPENDIX D

USE OF ESTUARIES FOR WATER TRANSPORTATION AND NATIONAL DEFENSE

Charles C. Kimm and Benjamin E. Perry

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APPENDIX D

USE OF ESTUARIES FOR WATER TRANSPORTATION AND NATIONAL DEFENSE

by

Charles C. Kimm and Benjamin E. Perry

INTRODUCTION

The nation's estuaries provide the physical, social, and economic parameters required for a system of water terminals serving international trade and coastal shipping. Similarly, estuaries support the national defense effort by providing natural harbors for military ocean terminals, berthing space for combat ships, storage areas for reserve fleets, protected water for ship construction and repair facilities as well as training and residential areas for service personnel involved in marine activities. Both uses affect the estuaries by (1) direct pollution and (2) encouraging modification of the estuaries' physical configuration to facilitate traffic flow. Furthermore, shore facilities, both active and abandoned, tend to dominate prime water frontage in areas of high-density populations.

TRANSPORTATION

The economic health of the United States is to a significant degree related directly to a port and shipping industry that can rapidly, safely, and inexpensively transfer imports, exports, and domestic trade between terminal points. The complex network of United States ocean ports provides an intrinsic economic asset that generates a vast dollar activity, a steady trade movement, and an external economy which permeates and strengthens virtually all phases of the nation's industrial and market structure.

Inventory of Estuarine Ports

Based on the Maritime Administration's "Listing of Existing Capital Plant of Ports and Terminals*, there were some 1,626 marine terminal facilities** in 1966 providing deep water berths located in 132 estuarine ports on Atlantic, Gulf, and Pacific coasts, including Alaska and Hawaii. These 132 ports do not represent all existing estuarine ports in the United States, but only those with marine terminals which can accommodate oceangoing vessels along side a pier or wharf with a minimum of 20 feet of berthing depth. These facilities can be considered the most significant ones from the standpoint of trade and commerce.

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*Maritime Administration, "Public Works Needs - Marine Port Facilities", Prepared for Joint Economic Committee of the Congress, June, 1966.

**A terminal is defined by the function which it serves (e.g., bulk cargo, livestock, etc.).

In 1965, the 132 estuarine ports handled 346,315,000 tons of foreign trade cargoes, which represent 78 percent of total U. S. foreign trade or 90 percent of all coastal ports' foreign trade. This estuarine port traffic in 1965 can be summarized as follows:*

Selected Estuarine Port Traffic - 1965
(in million tons)

Foreign Trade	Coastal	Local	Total
346.3	332.1	288.2	966.6

The geographical distribution of these estuarine ports by coast and by state is described in Table D-1.

No published data are available listing these ports' revenues. Based on records spanning a 17-year period, 1946-1962, the average annual modernization and rehabilitation expenses incurred by these 132 estuarine ports were estimated at $17,245,000. These expenditures include all additions, replacements, improvements, and restorative work to existing facilities which do not result in additional new berths. The Maritime Administration report also reveals that about $1.4 billion was spent on port terminal facilities between 1946 and 1962. Also, a total of $606 million is estimated as capital requirements for the port terminal facilities during the decade 1966 to 1975.

The Corps of Engineers Civil Works Program was formally initiated in 1824 and has subsequently facilitated the improvement of harbors and connecting channels in all coastal regions of the country and on the Great Lakes. Table D-2 summarizes investments made between 1824 and 1966 through the Civil Works Program in harbors and channels by coast.

The role of the largely estuarine system in maritime industry employment is indicated by the Maritime Manpower Report that provides employment data by seafaring, longshore, and shipyard classifications. These data are summarized in Table D-3.

The overall importance of an estuarine port to the economy of its community can be best illustrated by "The Port and the Community", a report on the economic importance of the New York/New Jersey Port to the people of the port district.

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*Corps of Engineers, "Waterborne Commerce of the United States", Calendar Year 1965.

TABLE D-1. DISTRIBUTION OF ESTUARINE PORTS BY COAST AND BY STATE

Coast	State	Number of Ports	Number of Terminals
Atlantic	Maine	3	18
	New Hampshire	1	5
	Massachusetts	6	77
	Rhode Island	1	19
	Connecticut	3	13
	New York[(a)]	1	294
	New Jersey	8	18
	Delaware	2	4
	Pennsylvania	4	71
	Maryland	1	89
	Virginia	4	68
	North Carolina	2	23
	South Carolina	3	21
	Georgia	2	23
	Florida	6	45
Gulf	Florida	7	48
	Alabama	1	29
	Mississippi	2	7
	Louisiana	3	105
	Texas	10	157
Pacific	California	19	222
	Oregon	8	68
	Washington	11	132
	Alaska	15	29
	Hawaii	9	41

Source: Department of the Army, Corps of Engineers.
(a) Includes 36 terminals located in New Jersey.

Highlights of the report include the following:

(1) The Port as an Employer. Port jobs provide livelihoods for at least 430,000 people and pay $2.1 billion in wages a year as a result of the movement of 140 million tons of commerce into, out of, and through the port each year. The detailed breakdown is given below.

TABLE D-2. SUMMARY OF OUTLAYS FOR COASTAL HARBORS BY U. S. CORPS OF ENGINEERS, 1824-1966

Thousands of Dollars

Coast	Outlays Through Fiscal Year 1966				
	Construction	Operation and Maintenance	Rehabilitation	Total	Non-Federal Cost[a]
Atlantic	547,444	493,786	4,139	1,045,369	52,610
Gulf	211,941	153,154	2,905	368,000	36,895
Pacific	212,424	192,687	17,402	422,513	83,465
TOTAL	971,809	839,627	24,446	1,835,882	172,970

Source: Department of the Army, Corps of Engineers.

(a) Monetary value of local contribution as identified in project authorization documents.

TABLE D-3. SEAFARING, LONGSHORE, AND SHIPYARD EMPLOYMENT

As of September, 1967 - Sea Coasts Only

Seafaring Jobs Aboard		63,782
Licensed	15,327	
Unlicensed	48,455	
Longshore		88,200
Atlantic Coast	50,400	
Gulf Coast	22,800	
Pacific Coast	15,000	
Shipyard - Commercial		52,773
MARAD Projects	6,652	
Navy Projects	30,095	
Private Projects	13,451	
Non-Ship Work	796	
Other	1,779	
TOTAL		204,755

Source: Maritime Manpower Report, Maritime Administration, U. S Department of Commerce (October 25, 1967).

Occupation	Annual Average Employment	Total Annual Payroll millions of dollars
Marine transportation	66,400	428.9
Auxiliary marine transportation	65,200	255.3
Marine construction	34,100	160.1
Land transportation	40,400	172.7
Port trade and finance	96,000	462.8
Port industries	127,600	657.7
TOTAL	429,700	2,137.5

(2) The Port as a Provider. Each of the 430,000 jobs is believed to create an economic equivalent of two additional jobs, or a total of 1,300,000 jobs. On the basis of 2.4 dependents per job, a total of 3,120,000 port district residents of a total population of about 13 million may be dependent for their livelihood upon the port's waterborne commerce, earning $6.3 billion in port-generated income, more than 25 percent of the total wages earned in the port district.

To summarize the economic implications of estuarine ports, the best source may be a report prepared by the Maritime Administration entitled "The Economic Impact of United States Ocean Ports". This study is in effect a nationwide, statewide, and selected individual port compilation and analysis with the primary purpose of determining the ecomonic significance of ocean and Great Lakes ports. Some of the highlights reveal that, with respect to domestic employment attributable to United States exports in 1960, a national total of 3.1 million workers was employed in direct export and export-related industries. Of this total, approximately 1.8 million represented workers employed in the 22 maritime coastal states and the District of Columbia to produce, transport, market and export merchandise. Using 1963 figures, the study also indicates that the 77 coastal and 40 Great Lakes ports listed earned about $5.6 billion in that year from the cargo passing through their ports. Many ports calculate the direct revenue to the port community of a ton of general cargo at about $16 to $20. Other types of cargo, such as petroleum, coal, ore, and grain, similarly produce direct by varying revenues. Applying these 1963 direct revenue factors to the 132 estuarine port traffic estimates in 1965, a conservative estimate of the dollar value of cargo earnings would be approximately $4.7 billion.

Environmental Effects of Commercial Watercraft

Despite the advantageous economic aspects of the nation's water transport system the same system has also created several serious environmental problems, particularly for the estuaries. First, commercial transport vessels have been shown to be significant contributors to estuarine pollution.* Commercial craft are estimated to be responsible for about 39 percent of the human waste loading from watercraft in the United States' waterways, or the equivalent of approximately 200,000 residents out of a total waterway occupancy equivalent of 513,000 persons in 1967.** While the level of all watercraft pollution rarely exceeds 5 percent of the entire drainage basin loading, the pollution from commercial watercraft is usually concentrated in a relatively small dock area of a harbor or in restricted navigation channels. Besides human wastes, commercial watercraft are serious - if not the primary - sources of polluted ballast and bilge water, litter, and oil discharges into navigable estuaries. In some cases, such as the rock phosphate carriers docking at Sacramento, California, or the floating crab canneries in the harbor of Kodiak, Alaska, commercial vessels are even significant sources of industrial-type pollutants.

A second, less manageable problem posed by commercial shipping is the physical development of the estuaries to service the transport system. Bulkheads are constructed as docks, navigational channels are dredged, and shore structures are raised for warehouses and maintenance facilities. Even the location of industrial, commercial, and residential structures in port cities is affected by the presence of commercial shipping. Commercial waterfronts are rarely considered places of urban beauty, and commercial shipping thus bears some responsibility for the degenerating physical circumstances that major cities of the nation are now experiencing.

NATIONAL DEFENSE

It is recognized that estuaries and, more specifically, ocean terminals are an essential element of the national defense system. It is also apparent that deep-water terminals exert a significant influence on the location of defense installations as well as industrial complexes necessary for logistical support of the defense effort. Even the mere fact that a resource is available when needed can be a significant contribution to the defense effort although it may be maintained in a standby condition without ever experiencing the need for activation. An example of this type of resource would be the reserve fleet.

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*For a comprehensive summary of the watercraft pollution situation, see: U. S. Department of the Interior, Federal Water Pollution Control Administration, Wastes from Watercraft, Report to the Congress, 90th Con., 1st Ses., Senate Doc. No. 48 (August, 1967).

**Ibid., p 48.

Quantification of the Department of Defense's overall dependence on estuaries is not feasible since most of the data available, such as fund expenditures, employment statistics, and investments in real property, are aggregated on an area or installation basis without any differentiation of estuary-related activities. However, the University of Rhode Island study, "Economic Impact of Narragansett Bay", Bulletin 374, December, 1963, by Niels Rorholm, clearly shows the overwhelming influence that Department of Defense activities can have on a particular estuary. Activities associated with Narragansett Bay were estimated to have an annual monetary impact of $145.1 million; of this amount, $132 million was attributed to naval payrolls.

In an attempt to assess the influence of estuaries on Department of Defense employment, it was found that the Economic Studies Division, Office of the Assistant Secretary of Defense (Systems Analyses), maintains employment data by location. These data are summarized for select coastal standard metropolitan statistical areas (SMSA) in Table D-4.

TABLE D-4. DEFENSE EMPLOYMENT IN DECEMBER, 1966

Thousands of Employees

Coastal SMSA	Civilians at Plants	Civilians at Installations	Military
New England	98.4	22.4	10.9
Middle Atlantic	199.8	95.6	92.9
South Atlantic	29.6	55.3	68.7
Gulf	9.9	15.6	28.4
California	273.9	115.7	173.0
Northwest	26.9	24.6	39.9
TOTAL	638.5	329.2	413.8
Continental U. S. total SMSA's	1,647.8	1,047.9	1,846.0
Coastal SMSA's as percent of total	38.7	31.4	22.4

Source: Economic Impact Studies Division, Assistant Secretary of Defense (Systems Analysis).

These employment figures in some way indicate the drawing power of coastal areas for Department of Defense-related employment. It should, however, be recognized that these employment statistics tend to overstate defense utilization of the estuarine system in that all employees in the coastal areas are not engaged in activities directly related to estuaries.

A more direct indication of the Department of Navy use of estuaries is the number of naval ships in commission. It may be observed from Table D-5 that this number has fluctuated between a high of 1,030 in 1955 to a low of 812 in 1960. The number of ships in commission during Fiscal Year 1967 was 931 with planned increase to 936 ships in 1968 and 960 in 1969. These vessels will require extensive shore-side logistical support facilities as well as berthing facilities, which will normally be located within or adjacent to the estuarine system.

TABLE D-5. DEPARTMENT OF NAVY COMMISSIONED SHIPS

1955 1,030	1957 967	1959 860	1960 812	1961 819	1962 900	1963 857
1964 849	1965 880	1966 909	1967 931(a)	1968 936(b)	1969 960(b)	

Source: Table 368, Satistical Abstract of the U. S. (1967).

(a) The Budget of the U.S. for Fiscal Year 1969.
(b) Estimated in Fiscal Year 1969 Federal Budget.

There are several economic indicators which demonstrate the significance of the economic impact of naval ships in operation. First and foremost are the funds allocated for new vessel construction as well as funds allocated for repair and modernization of vessels currently in operation. It can be seen from Table D-6 that this has averaged about $2 billion a year for the period 1959 through 1968.

Employment levels within naval shipyards have fluctuated between 83,800 and 98,400 during the period 1959 through 1967. In 1965 (the most recent figure available), the average annual payroll per employee was $7,268, which indicates that total national payroll from shipyards was in the vicinity of $674.5 million in 1967. The major naval shipyards included in the employment column of Table D-6 are Boston, New York (closed June 30, 1966), Portsmouth, Philadelphia, Norfolk, Charleston, Puget Sound, Mare Island, San Francisco, Los Angeles, and Pearl Harbor.

Closely allied to the expenditure of funds for construction, repair, and maintenance of the fleet are the economic benefits derived from modernization of naval shipyards. Senator Henry M. Jackson (Democrat, Washington) said in a speech at Bremerton that

TABLE D-6. NAVY BUDGET REQUESTS OR FUND AUTHORIZATIONS FOR SHIPBUILDING, REPAIR, AND MODERNIZATION

Fiscal Year	Shipbuilding, Repair, and Modernization, (a) millions of dollars	Number of Major Ships (b)	Naval Shipyard Employment,(c) thousands
1959	$ 1,381	20	96.7
1960	1,150	20	96.0
1961	2,032	44	98.4
1962	3,000	35	97.8
1963	2,900	37	93.9
1964	2,644	41	87.4
1965	1,966	53	83.8
1966	1,721	62	85.4
1967	1,756	47	92.8(3)
1968	1,824	34	
TOTALS	$20,374	393	

(a) Marine Engineering/Log, June 15, 1967, p. 157.

(b) September, 1967, Statistical Quarterly, Shipbuilders Council of America, 1730 K Street, N.W., Washington, D.C.

(c) Average first 7 months, 1967.

the planned long-range modernization for all naval shipyards would ultimately total $700 million. For Fiscal Year 1968, planned naval shipyard modernization expenditures totaled $30,988,000 to be distributed as follows:

San Francisco	$9,174,000
Boston	496,000
Philadelphia	1,526,000
Bremerton	6,923,000
Norfolk	6,943,000
Charleston	3,063,000
Long Beach	626,000
Pearl Harbor	2,237,000

At the present time there are 1,071 merchant ships in the National Defense Reserve Fleet; of these, 628 are maintained in a retention status. Ships in the reserve fleet are distributed as follows:

	Ships Not Maintained	Ships Maintained in Retention Status	Total
Hudson River	69	68	137
James River	164	122	286
Mobile	65	100	165
Beaumont	25	100	125
Suisun Bay	99	128	227
Olympia	21	110	131
Total	443	628	1,071

Very little is expended on the reserve fleet ships other than those held on a retention status. Average yearly cost per retention ship is $4,340 for preservation and cathodic protection and $2,246 overhead cost. Of the total appropriation of $5,440,000 for Fiscal Year 1968, it is estimated that approximately $2.4 million would be spent for personnel services. The number of ships in this fleet is diminishing quite rapidly as indicated in Table D-7.

TABLE D-7. NATIONAL DEFENSE RESERVE FLEET

Year	Ships Not Maintained	Total Ships in Retention Status	Total Ships in Fleet
1967	447	624	1,071
1966	495	731	1,226
1965	596	854	1,450
1964	709	941	1,650
1963	831	958	1,789

Since July of 1965, 161 retention ships have been taken out of the reserve fleet and placed in active service as a result of the Vietnam conflict. The economies realized by having these ships available for service when needed can be rather significant.

The Office of Congressional Requests and Special Projects, Chief of Naval Operations, maintains rather comprehensive payroll data for shore-based naval and marine military personnel and Department of Navy civilian employees. These payrolls may be obtained by state or city for the entire United States, however, it would be rather difficult to identify specifically the total payroll directly related to the estuarine system. The total payroll is shown in Table D-8 as an indication of the order of magnitude to be considered.

TABLE D-8. DEPARTMENT OF NAVY PAYROLL OUTLAYS FOR SHORE-BASED PERSONNEL (a) - 6 MONTHS, July 1, 1967 TO DECEMBER 31, 1967

Civilian	$1,534,848,000
Marine Corps, Active	360,104,000
Navy, Active	590,433,000
Marine, Reserves	12,000,000
Navy, Reserves	41,352,000
Total	$2,538,737,000

Source: CMD Report No. F637-0020, "Reporting of DOD Payroll Outlays by Geographic Location.

(a) Includes Continental U.S., Guam, Puerto Rico, Hawaii, Alaska, Midway, and Canal Zone.

Admiral Lawsen P. Ramage, USN, Commander MSTS, reported at the 1947 National Defense Transportation Association, Transportation Logistics Forum in Los Angeles, that "98 percent of the support for our military forces stationed throughout the world is transported in ships". This points up the need for an adequate system of ocean terminals to support overseas military operations. The Military Traffic Management and Terminal Service, Quarterly Progress Report (Parts I and II), shows all tonnage shipped overseas for Department of Defense and the cost for handling in-port operations involving both cargo and passengers. This is a most definitive indicator of defense use of the estuarine system. It can be observed from the extract of the fourth quarter FY 1967 report shown in Table D-9 that only a limited use is made of Great Lake ports. Total cargo operations for 1967 amounted to $20,835,500.

A gross summary of the national defense operations associated with the estuaries is as follows:

Personnel	
Employment in coastal SMSA's, 1966	
Civilians at plants	638,500 persons
Civilians at installations	392,200 persons
Military	413,800 persons
Payroll in Naval shipyards, 1967	$674,500,000

TABLE D-9. CARGO AND PASSENGERS TRANSHIPPED THROUGH CONTINENTAL UNITED STATES WATER PORTS

Part I

Cargo Areas	FY 1966		FY 1967	
	Measurement Ton, (a) thousands	Dollars, millions	Measurement Ton, (a) thousands	Dollars, millions
Total all areas	15,965.4	134.0	20,835.5	184.6
Eastern area	7,777.3	52.0	8,973.5	66.8
Atlantic ports	5,723.5	39.9	6,243.3	49.1
Gulf ports	2,030.0	12.0	2,635.5	17.0
Great Lakes ports	22.8	0.1	94.7	0.7
Western area	8,188.1	82.0	11,862.0	117.8
N. Pacific Coast (Washington-Oregon)	1,625.2	14.5	3,275.5	29.1
S. Pacific Coast	6,562.9	67.5	8,586.5	88.7

Part II

Passenger	FY 1966		FY 1967	
	Passengers, thousands	Dollars, thousands	Passengers, thousands	Dollars, (a) thousands
Total all areas	213.7	480.5	120.8	366.6
Eastern area	121.2	365.9	28.6	171.8
Atlantic ports	120.0	361.2	27.8	166.4
Gulf ports	1.2	4.7	0.8	5.4
Western area	92.5	114.6	92.2	194.8
N. Pacific Coast (Washington-Oregon)	(C)	(C)	10.2	21.6
S. Pacific Coast	92.5	114.6	82.0	173.2

Source: Quarterly Progress Report, Fourth Quarter FY 1967, RCSDD-1L (Q) 493, Military Traffic Management and Terminal Service, Washington, D.C.

(a) One measurement ton = 40 cu ft.

(b) Dollar amounts represent cost, not revenue, which is computed on predetermined billing rates.

(c) No movement reported.

Navy and Marine Corps pay and allowance for shore-based personnel and civilian employees for 6 months July through December, 1967	$2,538,737,000
Ships	
Naval ships in commission, 1968	936 ships
Maintenance cost of National Defense Reserve Fleet, FY 1968	$5,440,000
Expenditures for shipyard	$1,824,000
Expenditures for modernization of Naval shipyards, FY 1968	$30,988,000
Shipping	
DOD water terminal cargo handling costs, FY 1967	$134,000,000
DOD water terminal passenger handling cost, FY 1967	$ 366,600

Although some of these indicators overstate the national defense economic dependence on estuaries, they provide convenient order-of-magnitude estimates for evaluating the economic impact on the nation's estuarine system.

Environment Effects of National Defense

In some respects, the effects of national defense efforts have not differed significantly from those of commercial shipping in the physical impact on the estuaries. Very few of the approximately 700 U.S. Navy vessels operating in our territorial waters are equipped with sewage treatment devices; and less than a third of the 325 U.S. Coast Guard watercraft operating wholly in United States waters have even rudimentary sewage treatment facilities. None of the Maritime Administration's reserve fleet vessels activated for service by the Military Sea Transport Service (MSTS) during the Vietnam War have any type of sewage treatment devices. Thus, the national defense vessels (excluding MSTS vessels) account for about 28 percent of the human waste loading in the national waterways, the equivalent of approximately 140,000 persons.* Similarly, many of the shore facilities, particularly the urban shipyards, offer the same sterile appearance and indirect degradation for the estuaries.

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*U.S. Department of the Interior, FWPCA, p 48.

However, in a few cases, the coastal defense facilities, such as Forts Hancock (Sandy Hook), New Jersey, and the John F. Kennedy Space Center (Cape Kennedy), have preserved valuable estuarine coastline from indiscriminate development. Even here, though, the record is far from favorable since some valuable Department of Defense lands on estuaries have reverted to highly commercial and physically developed uses incompatible with general or recreational activities. One example would be the acquisition of National Park lands in the Florida barrier islands during World War II, then the postwar allocation of coastal tracts to private developers.

APPENDIX E

LAND RECLAMATION IN ESTUARINE ZONES

Gerald I. Nehman

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APPENDIX E

LAND RECLAMATION IN ESTUARINE ZONES

by

Gerald I. Nehman

INTRODUCTION

The purpose of this discussion is to describe the economic environment in which estuarine wetlands have been filled along U. S. coastlines. This will help to determine the economic motivations for filling wetlands as part of the overall task of defining the economic environment in which U. S. estuaries are being developed.

The research primarily uses data and information available in the literature. In some cases, though, these data have not been collected in a form available for an analysis of the economics of filled estuarine lands. These data gaps will be indicated through this discussion. When feasible, Chesapeake Bay is used as a case study for estuarine-wetland use. For this purpose, agencies concerned with landfill in the Chesapeake Bay were interviewed to supplement our knowledge of this particular area.

BACKGROUND

Wetlands have been filled for a variety of reasons. First, they have been used as spoil areas for muds dredged from navigation channels and as garbage dumps for coastal cities. Second, they have been drained for mosquito control, salt mining, and agricultural uses. Third, they have been filled for water-oriented uses, such as commercial port facilities and recreational boating. Fourth, they have been developed for land-oriented uses, such as housing, industrial sites, roadways, and airports. Historical land-use patterns on wetlands have been determined by the market price of the wetlands, development costs, and by the value of adjacent land. Qualitative factors, such as the esthetic quality of land and water, are now becoming more important as determinants of estuarine-development patterns. These factors are discussed as they relate to the future of estuarine areas.

The physical structure of the land-water interface in the estuary is a major determinant of the value of filled lands. Economic activity is generated by salt- and fresh-water fisheries; low-cost access to interior and overseas ports; protected bays for recreational boating, fishing, and swimming; and an abundant water supply. The physical characteristics of the coastal area also determine the cost of land development.

In addition to the physical structure of the land form, the proposed use of the filled land and the unit cost of the fill material determine total development costs.

The value and costs of filled land will help to explain historical land-use patterns on filled areas and will give some indication of what can be expected to develop in the near future. Major areas of conflict between the various users of the natural estuary and with users interested in filling wetlands are discussed.

QUANTITY OF FILLED ESTUARINE WETLANDS

According to a 1958 survey by the Bureau of Sport Fisheries and Wildlife, estuaries of the United States cover 26.6 million acres. This includes both shallow and deep-water areas. Some of these areas are not suitable as wildlife habitat; some are too deep to be considered as prospective landfill sites. The area of concern, therefore, is substantially less than the total acreage.

The Fish and Wildlife Services (FWS) in 1956 estimated that there were 9.3 million acres of shallow coastal fresh and saline areas in the United States. Only 1.3 million acres is open water covered to a depth of 10 feet or more. The bulk of the area is intermittently under water or under less than 3 feet of water.

In 1967, FWS estimated that there were 7.7 million acres of important estuarine habitat (Table E-1). The important habitat is primarily the shallow areas, which are also the most easily filled for development purposes. Thus, approximately 8 million acres of wetlands are feasible locations for landfill operations. This does not include deep areas filled by disposal activities where the cost of developing the land is a secondary consideration.

Coastal lands have been reclaimed in several metropolitan areas since the early part of the 1800's. In New York City, ships entering the harbor dumped their stone ballast along the Manhattan shore before loading with produce for European markets. This stone formed an excellent foundation for the construction of harbor facilities, and later for industrial sites and roadways.* FWS estimated that by 1958, 7.3 percent, or 564,000 acres of basic habitat has been filled. This estimate does not include dredge and fill in deep-water spoil areas, or acreage which dredged but later became suitable for wildlife habitat.

A large portion (45 percent) of the basic habitat filled was in California (see Table E-1). Most of this loss was in San Francisco Bay where 243 square miles of wetlands had been filled by 1957. This represents 43 percent of the land that was available for reclamation in 1850.**

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*"Dutch Treat for New Amsterdam", Engineering News Record, p 79 (January 12, 1967).

**U. S. Department of Commerce, "Future Development of San Francisco Bay Area-1960-2020", U.S. Army Corps of Engineers (December, 1959).

TABLE E-1. FISH AND WILD-LIFE ESTUARINE HABITAT LOST IN PAST 20 YEARS

State	Acres of Estuaries			Percent Loss of Habitat
	Total Area	Basic Area of Important Habitat	Area of Basic Habitat Lost by Dredging and Filling	
Alabama	530,000	132,800	2,000	1.5
Alaska	11,022,800	573,800	1,100	.2
California	552,100	381,900	255,800	67.0
Connecticut	31,600	20,300	2,100	10.3
Delaware	395,500	152,400	8,500	5.6
Florida	1,051,200	796,200	59,700	7.5
Georgia	170,800	125,000	800	.6
Louisiana	3,545,100	2,076,900	65,400	3.1
Maine	39,400	15,300	1,000	6.5
Maryland	1,406,100	376,300	1,000	.3
Massachusetts	207,000	31,000	2,000	6.5
Michigan(a)	151,700	151,700	3,500	2.3
Mississippi	251,200	76,300	1,700	2.2
New Hampshire	12,400	10,000	1,000	10.0
New Jersey	778,400	411,300	53,900	13.1
New York	376,600	132,500	19,800	15.0
New York (a) (Great Lakes)	48,900	48,900	600	1.2
North Carolina	2,206,600	793,700	8,000	1.0
Ohio (a)	37,200	37,200	100	.3
Oregon	57,600	20,200	700	3.5
Pennsylvania	5,000	5,000	100	2.0
Rhode Island	94,700	14,700	900	6.1
South Carolina	427,900	269,400	4,300	1.6
Texas	1,344,000	328,100	68,100	8.2
Virginia	1,670,000	428,100	2,400	.6
Washington	193,800	95,500	4,300	4.5
Wisconsin(a)	10,600	10,600	0	.0
Total	26,618,200	7,938,100	568,300	7.1
Total(b)	26,369,800	7,689,700	564,100	7.3

(a) In Great Lakes only shoals (areas less than 6 feet deep) were considered as estuaries.

(b) Great Lakes shoals omitted.

Source: U.S. Fish and Wildlife Service tabulation, p 46, hearings on estuarine areas, House Merchant Marine and Fisheries subcommittee on fisheries and wildlife conservation, March 6, 8, 9, 1967.

Other regions where large quantities of lands have been filled are around New York and Raritan bays; Tampa, Florida; New Orleans, Louisiana; and Texas. Around Long Island, for example, 12,635 from a total of 43,215 acres of wetlands available in 1954, had been filled by 1964 (see Table E-1). The annual rate of fill appears to be increasing, and the proportion of filled to unfilled areas rising. * Both the Gulf-Texas coast from Laguna Madre to Galveston Bay and the Florida bays (including Tampa Bay), are shallow areas with low freshwater intakes. ** This physical profile helps to explain the large quantities of lands that have been filled in these two areas (see Table E-1).

USES OF FILLED ESTUARINE LAND

The uses of filled estuarine lands are integrated with the uses of adjacent shoreline. Where the shoreline property is residential, filled land will probably serve residential or recreational uses. Harbor facilities on the shore are often extended onto filled lands or the filled lands are developed for industry which will use the water transportation network. Estuarine wetlands have been rated on the basis of the probability of imminent development. This estimate was made by evaluating the physical suitability of the land, population concentrations, and land ownership. In the 1956 wetlands inventory, this category included 4.8 million acres of shallow wetlands, or 18 percent of total estuarine area and 62 percent of the important habitat area.

Land use on filled estuarine lands has been estimated for Long Island and San Francisco Bay. In Long Island, primarily a residential area, 34 percent of the filled land is for residential development. Other uses are for miscellaneous fill (i.e., end use unknown), recreation, and industrial development (see Table E-2). The wetlands study in Long Island in 1964 placed 79 percent of the island's shallow coastal wetlands in this category. *** Filled land in San Francisco Bay was primarily for recreation, salt ponds, and agriculture (see Table E-3).

The development of Long Island landfill for housing and industry is a reflection of a more intensive use of land in the New York area. Also, San Francisco Bay is a more sheltered body of water than is Long Island Sound; and thus, is more conducive to uses such as agriculture and salt evaporation. In addition, the most attractive housing in San Francisco is on the hills overlooking the Bay area and not on the Bay itself.

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*S. P. Shaw and C. G. Fedine, Wetlands of the U. S., Supplementary Report - June 1965 on the Coastal Wetlands Inventory of Long Island, U. S. Department of the Interior, Fish and Wildlife Circular 39, Division of River Basin Studies, Boston (June, 1965).

**E. J. Wood and Furguson, Microbiology of Ocean and Estuaries (New York: Elsevier Publishing Company, 1967), p 185.

***Shaw and Fedine, op. cit.

TABLE E-2. USES OF FILLED COASTAL WETLANDS IN LONG ISLAND: 1964

Use	Acres	Percent
Housing	4357	34
Miscellaneous fill[a]	2505	20
Recreation	2094	17
Industry	1634	13
Marinas, docks, channels	732	6
Airports	479	4
Bridges, roads, parking	414	3
Waste disposal	177	1
Schools	108	1
Agriculture	96	1
Drainage	39	--
Total filled coastal wetlands	12635	100
Total coastal wetlands (1954)	43215	

(a) This term was used when ultimate use of the filled area was unknown.
Source: Supplementary Report June, 1965, on the Coastal Wetlands Inventory of Long Island, New York, U.S. Dept. of Interior, Bureau of Sport Fisheries and Wildlife, Region-V, Boston Massachusetts, p 9.

Dredge and fill in Florida have been mostly for residential development, and approximately 60,000 acres has been filled for this purpose. In most cases, the fill material has been obtained from adjacent bottom areas, improving access for recreational boats to the area. In Texas and in Louisiana, on the other hand, most of the landfill in estuaries has resulted from navigation projects. * This land is almost entirely undeveloped. Approximately 67,000 acres of marsh (about 16 percent of the total marshland) has been either dredged or filled in Galveston Bay alone.

Chesapeake Bay. It has been estimated by FWS that 1,000 acres of basic wildlife habitat has been lost in the Chesapeake Bay (Table E-1). On the other hand, a study conducted by the Maryland Department of Game and Inland Fish showed considerably more loss of wetlands in the Western Shore counties and the upper Eastern Shore counties of Kent and Queen Annes. Surveys conducted in 1955 and 1965 showed a loss of 28,500 acres or 36 percent of the original measured acreage. **

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*Charles Chapman, "Channelization and Spoiling in Gulf Coast and South Atlantic Estuaries", Proceedings of the Marsh and Estuary Management Sumposium, Louisiana State University, July 19-20, 1967, pp 93-106.

**Ibid., p 318.

TABLE E-3. USE OF RECLAIMED TIDE, MARSH, AND SUBMERGED LANDS IN THE SAN FRANCISCO BAY AREA: 1957

Uses	Acres	Percent
Residential and commercial	6080	4
Recreation	41856	27
Industrial	7488	5
Transportation	11200	7
Dumps and vacant lands	4480	3
Agriculture	36096	23
Salt ponds	38464	25
Military and other reserved lands	9728	6
	155392	100

Source: Future Development of the San Francisco Bay Area 1960-2020 U.S. Department of Commerce for U.S. Army Corps of Engineers, p 81.

SOURCES OF FILL

Harbor Maintenance and Navigation Channels

Dredging and filling for development purposes are occurring primarily in areas where population pressures have increased land values to levels that make the higher development costs economically feasible. These areas are primarily around northern New Jersey and New York City, San Francisco, and in southern Florida. Dredging to maintain navigation channels is more extensive than any other single activity throughout all the U. S. estuaries. Data have been compiled for the coast from Maine to Delaware. Even for this highly populated area, disposal of dredged spoil was the major reason for filling land (Table E-4). In addition, areas first used for spoil disposal often were later used for development projects. Thus, the economics of spoil disposal are often interrelated with the costs of land development.

Dredging activities to maintain channels in the estuaries is essential for the economic well-being of the country. Of the 170 ocean ports in the United States, 132 are located on estuaries.* These estuarine ports are excellent locations for port facilities and presently handle 89.5 percent of the total U. S. foreign trade. In addition, vessels must pass through estuarine areas to reach most of the nation's interior ports.

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*Ocean ports are defined as ports with facilities to handle vessels with 20-foot draft at dockside.

TABLE E-4. USE OF FILLED WETLANDS, MAINE TO DELAWARE: 1955 to 1964

Uses	Percent
Dredged spoil	34
Housing	27
Recreation	15
Transportation	10
Industrial	7
Dumps	6
Other	1
TOTAL ACREAGE	45,000

Source: Clark, John, Fish and Man: Conflict in the Atlantic Estuary, Special Publication No. 5 (American Littoral Society, Highlands, N.J.: 1967).

Channelization in the Estuaries

The Army Corps of Engineers is responsible for maintaining the nation's channels and harbors. The estimated budget for this phase of its work in FY 1968 was $83,027,000; its budgetary request for 1969 was $74,228,000. Approximately one-half of the 1969 budget request, or $36 million, was for projects in coastal areas. An additional $500,000 was requested for rehabilitation of navigational structures in one coastal area, Galveston Bay. *

The Corps does not compile data to determine either the total cubic yards of silt which it removes from channels and harbors or the total number of miles of channel maintained in a given year in the estuary. This information can be compiled on a project-by-project basis, however, by referring to the Corps' annual report. For example, 4.7 million cubic yards of material was dredged from harbors and channels around the Chesapeake Bay in FY 1966 at a cost of $2.2 million. The average unit cost was $0.59 per cubic yard, with a range of $0.30 to $1.89. For jobs over 70,000 cubic yards, the range was $0.21 to 0.81 per cubic yard (Table E-5).

This range of costs is quite large because of the wide variation in conditions under which dredging is conducted in Chesapeake Bay. The relevant cost-determining factors are depth of water and distance to spoil area, consistency of dredged material, exposure

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*U.S. Department of the Army, Corps of Engineers, Annual Report of the Chief of Engineers, U.S. Army on Civil Works Activities, 1966, Vol. 2, U.S.G.P.O. pp 259-288.

TABLE E-5. CORPS OF ENGINEERS DREDGING PROJECTS IN CHESAPEAKE BAY (1966) SHOWING QUANTITY DREDGED, PROJECT COST, AND TYPE OF DISPOSAL

Name of Project	Type of Project(a)	Total Material Dredged	Spoil Disposal(b)	Project Cost, dollars	Cost per cu. yd., dollars
Baltimore District	NW	2,992,903	O	1,486,216	0.50
Norfolk District	NW			550,140	--
Baltimore District	M	609,200	O	304,774	0.50
Baltimore Harbor	M	86,222		44,189	0.51
Black Walnut Harbor	M	14,300	O	15,742	1.10
Wicomico River	M	478,080	O, A	102,610	0.21
Bonum Creek, Va.	M	In progress		924	--
Crisfield Harbor, Md.	M	78,810	A	62,000	0.81
Duck Point Cove, Md.	M	19,300	A	17,263	0.89
Fishing Creek, Md.	M	15,900	O	30,000	1.89
Honga River and Tar (Barren Bay Island Gaps), Md.	M	86,400	O	55,000	0.64
Knapps Narrow, Md.	M	Condition surveys	--	1,778	--
Little Wiscomico River, Va.	M	Condition surveys	--	845	--
Muddy Hook & Tyler Coves (Dorchester County, Md.)	NW	96,020	A	58,551	0.61
Pocomoke River, Md.	M	In progress	--	--	--
Susquehanna River above and below Havre de Grade, Md.	M	187,668	O	55,850	0.30
Tilgham Island Harbor Md.	NW	In progress	--	--	--
Tred Avon River, Md.	N	Condition surveys	--	379	--
Twitch Cove and Big Thoroughfare River, Md.	M	29,977	A	25,000	1.09
Upper Thoroughfare, Deal Island, Md.	M	In progress	--	2,886	--
		4,683,780		2,781,147	0.59

(a) New Work = NW; Maintenance = M.

(b) Overboard = O; Ashore = A.

Source: 1966 Annual Report for the Fiscal Year Ended June 30, Chief of Engineers U.S. Army Civil Works Activities, Department of the Army Corps of Engineers, Vol. 2, U.S.G.P.O., Washington.

of the particular location to weather, the degree to which the spoil area must be prepared, and the amount of preliminary engineering work that is required. Because of the many variable factors in the costing of projects, there has been very little attempt to analyze dredging costs to define trends over time or to set up uniform means for computing costs of removing material from estuarine areas.

In 1958 the Corps of Engineers submitted a report to the U. S. House of Representatives Appropriations Committee to discuss the desirability of purchasing additional government dredges. As part of this report, the Corps measured the cost of dredge operation in terms of capital requirements, labor and fuel costs, and normal profits. They also considered specific job characteristics such as length of pipeline, abrasiveness of material, and development requirements at disposal areas. It was estimated that the dredging industry within the continental United States has an annual earning capacity of $85 million on an 8-month utilization basis (except for the North Central and North Pacific areas, where a 6-month period was used). The federal program for FY 1958 for this type of equipment required a capacity of $32 million, or 38 percent of the dredging industry's earning capability. At the same time, the Corps had an earning capability of $4. 8 million using its own equipment.

Based on the above analysis and on discussions with the industry, the Corps estimated that federal and private work divided the capacity fairly evenly, though data on the quantity of private dredging was not available. * It must be kept in mind that this analysis was for all the Corps' work so it is not directly applicable to United States estuary activity. The overall conclusion, however, that approximately one-half of the dredging in the United States is conducted by private parties, probably can be assumed relevant to estuarine activity.

DISPOSAL PRACTICES

Dredging conducted by the Corps of Engineers is usually at the request of local interests who provide areas for the disposal of the spoil or approve the Corps' selected site. Since the federal government does not recover any of its cost by direct use of dredged material, the Corps is motivated to find a site that is close to the dredge area and that requires a minimum of preparation.

Overboard Disposal

Spoil may be pumped from the dredging site to a distant deep-water site or it may be distributed on adjacent shallow areas. Pumping onto adjacent shallows is less

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*Analyses of Dredging Costs and Relationship to Corps of Engineers Dredging Program, Report of the Corps of Engineers to the Senate Public Works Appropriations Committee, Hearings (1959), pp 6-7.

expensive but the deposits are then susceptible to re-suspension due to wind-wave energy. During the period of adjustment to equilibrium, the spoil material may tend to drift into deeper water, hence requiring periodic maintenance of the dredged area. In addition, spoil deposited in shallow areas destroys less mobile bottom fauna and fluora.

Deep-water spoil disposal is less destructive since the flora population in these areas is less dense and the fauna species are more mobile. If a deep canyon is chosen for deposition it acts as a natural container and reduces the spread of spoil material. Reduced wave action at greater depths has the same effect.

The spoil from the Baltimore Harbor maintenance project is deposited overboard in a canyon near Kent Island. The oyster industry is presently opposed to extending the spoil area southward in the canyon because of anticipated damage to oyster beds. The Corps claims that the nutrient enrichment has an overall beneficial effect on the area's wildlife. The present spoil site is an excellent sport-fishing area.

Effects of Overboard Disposal on Wildlife. Dredged material pumped overboard increases the silt level in the water. The normal silt level will depend on water turbulence, the direction and velocity of coastal currents, and the rate of soil erosion from higher surrounding elevations. Overboard disposal should be evaluated in light of these natural phenomena. Studies conducted to determine the effect of overboard disposal of spoil have obtained conflicting results.

The effects of dredging on oysters was studied in shallow bays of Louisiana by John G. Mackin of the Agricultural & Mechanical College of Texas under a grant sponsored by four large petroleum companies. Three dredging operations were examined: a hydraulic dredge depositing a spoil island, a clam dredge operating in a canal, and a hydraulic dredge depositing in a half-fan circle. The results showed that the silt sitrred up by the dredge was carried a maximum of 1300 feet with rapid dispersal by dilution and sedimentation. A maximum of 1 percent of the material was observed to be drifting away from the site of deposition. Turbidities beyond a few hundred feet did not exceed the natural levels and no harmful effects were observed on the oyster beds. He concluded that oxygen depletion with dredging in Louisiana marshes was a relatively minor factor and not responsible for fauna and flora mortality. *

A study was conducted in Narragansett Bay on the effects of overboard spoil disposal on lobsters. Water samples were taken before and during dumping. Lobsters were observed in baskets placed on the periphery of the dumping site and under laboratory conditions. They concluded that "mature lobsters will tolerate concentrations of

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*John G. Mackin, "Canal Dredging and Silting in Louisiana Bays", Institute of Marine Science Publication, University of Texas, Vol. 7 (1961), pp 262-314.

suspended material as great or greater than those resulting from the discharge of dredged sediment". *

A study of sediment dispersal around spoil islands in Redfish Bay near Aransas Pass, Texas, was conducted by T. R. Hellier, Jr., and L. S. Kornicker, Institute of Marine Science, University of Texas. The purpose of the study was to determine the effect of dredging on marine life. Studies of conditions before and after sediment deposition in the bay showed that erosion from the spoil island was deposited less than 1 mile from the spoil bank. Beyond 0.5 mile, siltation had little effect on the existing biota. **

Heavy covers of loose and water anaerobic muds have been observed near dredged areas. These muds can be tolerated by only a few forms of animal life. When the Julia Tuttle Causeway was built in the early 1950's in Biscayne Bay, Florida, bottom vegetation, including a mixture of algae and sea grasses, was eliminated over an area more than a half mile south of the causeway site. *** A second incident has been documented in Hillsborough Bay, Florida. In 1966, when an improperly diked fill site spread muds over 250 to 300 acres of adjacent bay bottoms, access to the area by boatsmen became limited due to the muds, and vegetation was completely destroyed. An island bird sanctuary became surrounded by the muds which precipitated a drastic decline in nesting populations of American egrets, brown pelicans, cormorants, and wood ibis. No practical means of removing the mud has been suggested. ****

Though opinions differ as to the effect of the dumping of silt in shallow and deep areas, it is clear that there is a dramatic physical alteration at the dredge and at the fill site. Natural habitat is obviously lost when the fill area is made into land. The dredge itself is equally destructive when an area becomes too deep for light to penetrate and support bottom vegetation.

Conservationists' most difficult task is to show how the production of a particular estuary is affected by each incidence of dredge and fill. Ultimately, in order to do this they must be able to document a decline in production with each increment of dredging activity. It would then be possible to conclude, for example, that destruction of 10 acres of wetlands in Chesapeake Bay would result in a decline of 1 percent in the productive ability of the bay. The cost of a 1 percent decline in productivity could then be determined.

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*S. B. Saila, T. T. Polgar, and B. A. Rogers, Results of Studies to Dredged Sediment Dumping in Rhode Island Sound, Graduate School of Oceanography, University of Rhode Island, Kingston (undated), p 44.

**Thomas R. Hellier, Jr., and Louis S. Kornicker, "Sedimentation From a Hydraulic Dredge in a Bay", Institute of Marine Sciences, University of Texas, Vol. 7 (1961), pp 212-215.

***W. R. Marshall, "Practices Affecting South Atlantic and Gulf Coast Marshes and Estuaries Dredging and Filling", Bureau of Sports, Fisheries, Vero Beach, p 6.

****Ibid., p 6-9.

As a first step, a study has been conducted by Sykes and Finucane to examine the overall effect of bay alteration on a large number of species of juvenile fin fish and shellfish.* They compared Old Tampa Bay and Hillsborough Bay and found the latter to be less productive. Hillsborough Bay has been more altered by bay filling. Since bay filling is usually associated with population concentrations and the resulting higher pollution levels, it was not possible to separate the two effects. However, until we are in a position to control our waste outflows, analyzing these two effects together may be justified.

The Chesapeake Bay. High land values on the western shore of the Chesapeake Bay has forced the Army Corps of Engineers to decrease on-shore dumping of spoil and to increase the practice of overboard disposal. In 1966, there were 11 dredging jobs in the Chesapeake Estuary where the spoil area was specified; 7 were in overboard locations (see Table E-5).

Studies have been conducted by the Corps to show that overboard disposal of spoil from the dredging of the Chesapeake and Delaware Canal will not harm nursery areas in the upper bay. Their conclusions were based on the timely phasing of the dredging to avoid disposal during the spawning season. Biologists hired by the State of Maryland disagree with the Corps' conclusions. Alternative dumping sites have been suggested on Federal property at Aberdeen Proving Grounds. The adoption of this plan would increase the project's cost $33 million and delay its completion 1 year, according to the Engineers.**

A study of spoil-disposal practices has been conducted in the Chesapeake Bay by the Natural Resources Institute, University of Maryland. An interim report entitled "Gross Physical and Biological Effects of Overboard Spoil Disposal" has been released by the Institute. This report considered the effects of dredging on the geology and hydrography, phytoplankton, fish eggs and larvae, and adult fish. Sediments were found to spread over an area at least five times as large as the designated disposal area. The nutrient chemical outflow was equivalent to the sewage from a town of about 10,000 people. No gross effects were observed on the microscopic plants and animals in the water, on the eggs and larvae of fish, or on adult fish held in cages near the outflow or caught near the area. In a wide area, some bottom animals were smothered, other species survived deposition, and certain species began repopulation immediately.***

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*Ibid., p 11.

**Estuarine Hearings, Chesapeake and Delaware Canal (March, 1967), p 182.

***Chesapeake Biological Laboratory, "Interim Report on Gross Physical and Biological Effects of Overboard Spoil Disposal", Natural Resources Institute, University of Maryland (May, 1967).

CONCENTRATED SPOIL DEPOSITS

Spoil has been dumped on wetlands adjacent to the shore, in banks adjacent to the dredged channel, and in off-shore islands. Many of these deposit areas eventually have been used as a base for further development. In the Houston Ship Channel, muds have been dumped in a long bar extending down the length of the channel.

The dumping of dredged material in bars adjacent to the channel is more common in less populated areas. It is the principal means of disposal when channels are dredged to gain access to near-shore drilling rigs in the Gulf of Mexico. This practice often cuts off large sections of the estuary from swimming species, and the stagnant pools that are left behind the bars have little biological value. Furthermore, in many parts of the country, the bottom muds in the waterways are polluted. When they are deposited in bars or islands, they create unpleasant odors, and are esthetically unattractive. For other than commercial users of the waterway, the bars may act as barriers to cross-channel traffic, eliminating access for pleasure craft to the channel from on-shore entrance ramps. It is possible, on the other hand, that under some circumstances these bars may serve as locations for oyster beds, and as nutrient-rich areas for other forms of wildlife. This positive contribution has been claimed by the Corps on some occasions.

In the Chesapeake Bay, the Department of Natural Resources has requested that spoil be deposited in islands to serve as wildlife sanctuaries. A harbor-channel project now under consideration includes plans for dumping material in a spoil island to be developed for recreation. One island in the northern part of the bay already has been developed in this way. A third island is being proposed south of Havre de Grace. The development of these islands for recreation has countered some of the initial resistance to this means of spoil disposal.

EXAMPLES OF INTENSIVE SPOIL-SITE DEVELOPMENT

Spoil sites have been used intensively for industrial development around port areas for many years. Since the early part of this century, dredged spoil in the port of Portland, Oregon, has been used to develop industrial sites on Swan Island. This island is now almost entirely a product of dredged material; and, besides providing land for an airport and a shipbuilding yard, there is adequate acreage for a light-industry park and an industrial complex for 50 firms. *

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*"Dredge Clackamas", Harbor News (September, 1962).

Building Construction

In Jersey City, New Jersey, a 12-story apartment building is being constructed 300 feet offshore in the Hudson River estuary on the site of an old ferry ship. This $3.4 million structure will be elevated 50 feet over the water to exploit a spectacular view of New York City and the Hudson River, and will be connected to the mainland by a roadway which encircles the structure. *

A similar project is underway on Manhattan's East River shore. A 6-acre triangular platform supported on piles will be the site for a complex of apartment towers, townhouses, and multilevel commercial and recreational plazas. Just south of this platform and connected to it will be a new United Nations International School built on a platform supported by piles and fill material. **

Foundations for the support of structures for apartment buildings or industrial plants are more expensive on most fill material than on adjacent land where more consolidated material or a firm rock base may be available. Flat paved areas such as roadways, parking lots, and open storage areas, require less-demanding site preparation. Though the foundation must be stabilized, the weight is distributed over a wide area. If some settling does occur the cost of filling and repaving is low. For example, many of the major highways entering New York City pass through the New Jersey meadows on landfill. Though some of these roads have presented stabilization problems in the past, they have not been serious.

Airport Location

Early airport location was haphazard. Some airports owe their origin to a county fair performer who used an open field outside of town to land and refuel. Others were started by private companies who built landing strips adjacent to their plants. Whatever their origin, many of today's urban airports are experiencing location problems because of over-congestion, new construction obstructing approaches, and objectionable noise levels over residential areas. Several coastal cities already have located their airports on, or adjacent to, estuaries and are anticipating expansion into the water. *** Several West Coast cities are proposing radical airport design to allow them to locate in estuarine and coastal areas that are isolated from the densely settled urban environment.

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*"Offshore Building Shows Way to Revise Waterfronts", Engineering News Record (October 6, 1966).

**The New York Times (November 15, 1967).

***Airports located on estuarine coastline include Boston, New York (Kennedy and LaGuardia), Washington, Norfolk, San Diego, San Francisco, and Oakland.

The incidence of planes hitting urban structures are rare events relative to the number of successful landings and take-offs at major urban airports. Most U. S. cities have taken precautions to keep tall structures away from airport approaches so that most of the accidents which do occur are from overshooting or undershooting runways. This problem is of minor importance as compared to the nuisance generated by high noise levels emanating from low-flying jet aircraft.

Noise Pollution. At the present time, one of the main barriers to the construction of new airports is adjacent property owners aversion to noise. This was asserted by General William F. McKee, Federal Aviation Administrator, at a meeting before the Society of Automotive Engineers in Los Angeles.* In 1967, there were 175 lawsuits initiated by individuals and groups of private citizens against airlines because of damages incurred by noise and for damaging vibrations. Claimants have been relatively unsuccessful in the past but more relevant data is being collected as intense sound waves reach more and more people. A man living one-half mile from the northwest runway of Kennedy International Airport expressed his problem in the following manner:

> "They're using the runway tonight, I wish you could feel the walls. When they take off, it's like they were shooting at us.... There are cracks in the walls. The beams are giving way in the basement. The floor slants... If you were here you could smell the fuel. I honestly think its getting to us... Either the New York Port Authority moves the airport or it moves me."**

Airport agencies in New York, New Jersey, and several West Coast cities are considering water sites to reduce the unpleasant effects of low-flying jetliners.

Locating airports on the edge of the estuary is desirable because of less reverberation and less people to disturb. The costs of providing rapid transit to the city are very high but estuarine locations can usually be closer to downtown areas than comparable facilities in the suburbs.*** Though the cities are close, the danger of running into structures usually can be avoided by arranging flight patterns to enter and leave the airport over water. Runways for San Francisco Airport, International Airport in Washington, Kennedy and LaGuardia Airports in New York, and Newark Airport, to name a few, have some facilities constructed on filled estuarine wetlands. In addition, several new projects are being planned to develop wetlands for airport use.

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*Evert Clark, "Noise Called Bar to New Airports", The New York Times (October 5, 1967), p 79.

**Robert Sherrill, "The Jet Noise", The New York Times Sunday Magazine (January 14, 1968), p 24.

***Costs of rapid transit are approximately 1 million dollars per mile for a highway, 2-3 million dollars per mile for monorail, or 5-8 million dollars for a subway.

The three West Coast cities, San Diego, Seattle, and Los Angeles presently are considering Pacific Ocean locations for landing fields to be built on piers, pontoons, or landfill. San Diego is considering a proposal to obtain fill material from a dredged cut through Coronado Silver Strand, a project proposed by the Corps of Engineers. Off-shore locations are more costly but it is felt that the long-term benefits will justify the added expenses. *

Limitations of Estuary Locations. Though airports may be planned to minimize the noise nuisance, the possibility always exists for neighbors to move too close and thus become exposed to high noise levels. Homes are sometimes sold near airports to families who are fully aware of the noise problem but who do not realize the effect it will have on their daily lives. It does not take them long to join citizen-action groups to complain about disrupted conversations during dinner or television interference during the 7:00 news. Zoning laws must be enforced to control encroaching land uses, if airport planning on estuaries is to be effective. In San Francisco, for example, a developer is seeking a permit to build houses on filled wetlands under one of the final approaches to the airport.

New York airports have had more problems with air traffic than most other cities. Recommendations have been made to zone lands adjacent to airports for compatible uses and to divert some traffic away from Kennedy International. To appease residents of communities surrounding its airports, the Port of New York Authority has placed noise-recording instruments at ground level under flight paths and has agreed to keep recorded noise levels below 115 decibels. Pan American Airlines reportedly stations a man on the ground to warn pilots when to reduce power so as to quitely pass the "black" boxes, after which they proceed normally, a maneuver known as "beating the box". The boxes around Kennedy International have been set up since 1960. **

At first glance, it appears that estuaries can be used to absorb airplane noise, minimizing the effect on the surrounding communities. Wetlands set aside for this purpose could continue to serve as natural habitat if the noise and the vibrations do not disturb this environment. Studies should now be conducted to determine if, in fact, the noise will have a minimal effect on the large number of species living in shallow waters.

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*"Big Jet Airport May Go Off Shore", Engineering News Record (February 2, 1967).

**William E. Burrows, "Hush-Hush Agent Helps Airlines Beat Noise Ban", The New York Times (October 18, 1967).

VALUE OF WETLANDS

Determining Value

The value of filled wetlands will depend on (1) the value of lands in the immediate vicinity, and (2) the quality of the land that is created by the fill material. Since both of these factors will vary from site to site throughout the country, no general conclusions can be drawn. For the time being, it will have to be assumed that lands are filled for development because market conditions favor this development. That is, there is not an a priori reason to assume that land developers are making excess profits or are assuming excessive costs for their work. Since development costs also include acquisition costs, individuals interested in using the land in its natural form have an opportunity to enter the market and help determine its use. There are some users, however, who for various reasons are normally excluded from this market.

Users of the natural estuarine wetlands are not in a position to express themselves in the market for estuarine land. Organizations of oyster fisherman have never attempted to purchase rich oyster beds in order to protect their source of incomes; organized commercial fisherman have not tried to purchase coastal wetlands to preserve nursery and feeding areas. One reason for this lack of land-market participation by commercial users is that there is no way to stop outsiders from benefitting from the preserved land; that is, there is no way for the land owners to control the benefit stream from the land holdings. A second reason why commercial users may not participate in the land market is that their profits from selling on product markets do not justify a land investment. In either case, the stream of values to users of natural habitat must be determined outside of the market in order for their needs to be included in land-management decisions.

There are a few notable exceptions where lands have been purchased by private groups to preserve their natural productivity. These groups are primarily conservation oriented with membership among the 8,200,000 bird watchers, 1,650,000 waterfowl hunters, and 8,500,000 saltwater anglers in the United States. *

Since rigorous tools have not been developed for determining the dollar value of undeveloped estuary lands, natural value will be decided by political action. Such groups as the Natural Conservancy, the Izaac Walton League, the National Wildlife Foundation, the Sport Fishing Institute, and many local chapters of the Audubon Society are attempting to influence the political establishment by indicating, with a dearth of facts and an abundance of pictorial case studies, the value of these lands to their natural users. The Natural Conservancy, in particular, has taken positive action by purchasing valuable estuarine habitat for public use.

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*Polly Redford, "Vanishing Tidelands", Atlantic Monthly, No. 219 (June 20, 1966), p 78.

Value of Filled Lands

The value of some of the filled lands discussed previously has been estimated. The offshore islands in Long Beach which serve as sites for oil rigs cost $185,000 per acre: the cost of developing a peninsula, also a part of the project, was $63,000 per acre. It was estimated by the developers that the prorated cost per well site is $10,000 as opposed to a cost of from $20,000 to $150,000 per well site for conventional equipment. Using the low estimate for cost of conventional equipment, the value added per well site is $10,000, though this is admittedly an exceptional case.

The value of the proposed filled land in the port of Baltimore has been estimated to be $20,000 to 25,000 per acre. The acquisition and development costs for this land are going to be approximately $16,000. Thus, the Port Authority estimates a net return of from $4,000 to $9,000 per acre. Again using the low side of the range, the 90-acre land development project is returning approximately $360,000. *

Costs of Developing Wetlands

The costs of filling wetlands for development varies considerably depending on:

(1) Quantity and quality of fill required

(2) Distance which fill must be transported

(3) Nature of the structures which the land is being designed to support.

A survey of 10 fill projects in San Francisco Bay from 1938 to 1958 indicated an average cost of $8,300 per acre (unadjusted price levels). The California State Division of Water Resources, in 1955, estimated costs of reclaiming San Francisco Bay wetlands. Their estimates ranged from $22,000 to $27,000 per acre for filled land. On the basis of a 50-year amortization of capital costs at 3 percent, and including operating and maintenance costs, the annual cost of reclamation would be between $860 and $1060 per acre for filled land. **

The costs of filling land from dredged material have not been isolated from the standpoint of the fill project per se. Lands are often filled-in with spoil and then not developed for 10 to 20 years while the material dries and settles. The owner of the land does not pay for this type of material, however, since he is considered to be performing a service by allowing his land to be used as a spoil dump. If he chooses to develop the land, his costs are those incurred in working with the spoil-filled site.

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*Personal interview, Richard W. Tyler, Maryland Port Authority.

**U. S. Department of Commerce, "Future Development of San Francisco Bay Area - 1960-2020", U.S. Army Corps of Engineers (December, 1959).

On the other hand, there are some costs that are incurred by the users of dredged waterways which can be determined. Here again, however, cost figures are available on a project-by-project basis with great variations among projects and little to be gained by aggregating them.

MEANS OF ADMINISTRATIVE CONTROL OF WETLANDS

The United States has an estimated 27 million acres of Atlantic, Gulf, and Pacific coast estuarine area and Great Lakes shoreline. Approximately 8 million acres of this total is considered basic fish-and-wildlife habitat and is of primary concern to conservation management, Legislation is being sponsored in the House of Representatives to control the effects of dredging and filling on the wildlife values of estuaries. The Dingell Bill, proposed by John D. Dingell, chairman of the House Fisheries and Wildlife Committee would do the following:

(1) Provide for a study by the Department of Interior to determine the estuarine areas to protect

(2) Permit Interior to manage estuarine areas owned by state and local governments

(3) Allow Interior to establish national estuarine areas, with Congressional approval

(4) Provide that there may be no dredging, filling, or excavation in any estuary without a permit from Interior or from an appropriate state agency established to protect the scenic, and fish and wildlife values of estuaries.

This bill was initiated by Congressional dissatisfaction with the Corps' present practice of consulting with the Department of Interior on issuance of dredge and fill permits. The Fish and Wildlife Service has been making recommendations on Corps' permits for a number of years with limited success. In 1962, for example, FWS recommended that the Corps deny permits in 18 cases, of which 10 were issued. In 1963, the Corps approved 2 out of 11 permits that FWS opposed. From 1963 to 1966, the Corps did not comply with 11 percent of the modifications or denials suggested by FWS. The Corps received about 5,000 applications in 1964-66, and FWS objected to 193. After modifications, 8 were denied and 147 were granted. Thirty-eight of those granted were against FWS recommendations. Conservationists are dissatisfied with both the Corps' acting against FWS recommendations and with the small number of permits to which FWS objected. In addition, FWS does not review dredging conducted by the Corps for harbor and channel maintenance.

In June, 1967, the Secretary of Interior and the Secretary of the Army exchanged "Memorandum of Understanding" to jointly review dredging permits on the basis of controlling pollution and conserving fish and wildlife, recreation, and esthetic values in the estuaries. This is the first time that the Corps has been given other than navigational criteria for deciding whether or not to issue permits for dredging. There has not been sufficient time to evaluate the effectiveness of this agreement. Proponents of the various bills that have been proposed would like the Secretary of the Interior to approve any dredging, filling, or excavation work within any estuary.

Studies are being conducted to provide a data base for making management decisions for estuarine uses. The Estuarine Technical Coordinating Committee (ETCC) of the Gulf States Marine Fisheries Commission has joined with others to investigate the effects of pollution, dredging, and construction to learn how to continue most of these activities and at the same time mitigate their effects on the natural productivity of estuarine areas.

Even with increasing populations, several factors may contribute to a change in the rate of fill of wetlands. First, as development proceeds, the shallow waters will be filled because of lower development costs. It may take a long time for the filling of deeper wetlands to be economically justified. Second, new technology may shift the demand for land. Building skyscrapers, building underground, building on very steep slopes, or on unstable foundations all reduce the pressure for the use of filled welands. These alternatives must be included in a management program attempting to alter the existing patterns of land development.

Conflicts emerge in estuarine management because of the diverse commercial, and recreational users of these areas. Many people are themselves multiple users, as is, for example, the fisherman who uses the dredged channel as a path to reach productive fishing areas, or the land developer who depends on the esthetic characteristics of the bay to maintain the value of his newly filled land. These multiple users will continue to complicate the decision-making problems of politically responsive groups who are trying to deal with conflict situations.

SUMMARY

The following is a list of effects that dredge and fill have on the natural characteristics of estuarine lands:

Detrimental:

(1) Reduction in water area

(2) Denuding of areas of fill material from the bottom

(3) Changes in current, salinity, and water temperature (these may be beneficial as well)

(4) Reduction of access to water areas by near-shore spoil areas

(5) Temporary increase in siltation level in the water.

Beneficial:

(1) May provide nutrients that can attract large fish populations

(2) May serve as launching ramps for recreational boats

(3) Help control the salt-marsh mosquitoes.

This Appendix has discussed the reasons why estuarine lands have been dredged and filled and the effects that these activities may have on the various users. Though the beneficial and detrimental effects are enumerated, they are not easy to identify on a project basis. Further analysis is needed to better understand the overall impact that channel maintenance has on a particular estuary.

An attempt was made to enumerate the costs of dredging and the value of filled lands. Data are not available to give a complete picture of the economic parameters which, at least partially, are directing use patterns on filled estuaries. In order to obtain this information, detailed surveys of coastal landfill projects must be conducted to measure the real development costs and the market value of the new real estate.

APPENDIX F

ECONOMIC VALUE OF EXTRACTIVE INDUSTRIES IN THE ESTUARINE ZONE

Raymond W. Hale

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APPENDIX F

ECONOMIC VALUE OF EXTRACTIVE INDUSTRIES IN THE ESTUARINE ZONE

by

Raymond W. Hale

INTRODUCTION

This appendix reviews the extractive uses of estuarine waters and bottoms. Woefully inadequate data, however, provide a severe limitation in comprehensively describing either the location or scale of extractive operations. Several circumstances contribute to this situation. In many publications, extractive activities are described as being "offshore", or the area specified is simply the continental shelf. No significant primary reference sources for the extractive industries explicitly relate production statistics with the estuarine zone. Nevertheless, extractive activities are occurring in estuaries and these operations can be divided into three general groups:

(1) Mining of materials from below the estuarine floor; e. g., sulfur and petroleum

(2) Mining of materials directly from the estuarine floor; e. g., sand and gravel

(3) Extraction of materials directly from the water; e. g., magnesium metal.

Each of these groups poses its particular problem for future management of estuarine areas.

MINING OF MATERIALS BELOW ESTUARINE FLOORS

Petroleum

Economic Significance of Offshore Wells. Only a minute fraction of the total U. S. drilling for petroleum is occurring in the estuarine zones, and even this restricted activity has been concentrated in coastal areas of four states: Louisiana, Texas, California, and Alaska. Offshore drilling operations, however, are gradually being extended to the coastal areas of other states, including Florida and Oregon. Furthermore, even when offshore operations are not located in the estuaries, drifting pollutants from deeper waters, spillage from pipelines and tankers, and the physical modifications required for service traffic still exert an influence upon the ecology and quality of the estuaries.

Forcing this expansion of offshore petroleum production is a steadily rising world demand for petroleum coupled with a relative decline in the discovery of new inland fields. From an estimated 8 percent of the free world's petroleum supply in 1962, the percentage pumped from offshore areas had approximately doubled by 1966.* In 1967, the offshore petroleum output of the United States was approximately 900,000 barrels per day compared to a total production – inland and offshore – of approximately 8,800,000. In Louisiana, the number of onshore rigs dropped from 325 in 1959 to 175 in 1967, while offshore rigs doubled from 50 to 100 during the same period.** Only this offshore activity appeared to prevent Louisiana from suffering the same decline in drilling that was plaguing the rest of the nation. The total wells drilled in Louisiana and its offshore areas numbered 360 in 1959 compared to 270 in 1967, a decline of 25 percent, while the national drop was 50 percent. On a regional basis, the anticipated drilling activities for 1968 are described in Table F-1.

TABLE F-1. UNITED STATES OFFSHORE ACTIVITY OUTLOOK FOR 1968

Region	Number of Wells	Average Number of Rigs Running	Estimated Platform Installations
Gulf of Mexico	950	95	68
Alaska	120	23	3
West Coast	175	28	6
Totals	1,245	146	77

Source: "Petroleum Industry Outlook/Direction, 1968," Petroleum Engineer (January, 1968), pp 49-63.

These figures do not include the accelerated drilling activity from four man-made islands in the East Wilmington field in the Long Beach, California, harbor. An average of two wells each week is being completed by four rigs installed on each of these islands.

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*Frank N. Ikard, "Offshore Petroleum Recovery – Status and Outlook," Supplement: Transactions of the Second Annual MPS Conference and Exhibit, Marine Technology Society (June 27-29, 1966).

**"Louisiana's Future Taped to Offshore," The Oil and Gas Journal (June 19, 1967), p 73.

However, the figures of Table F-1 do include the 75 to 80 newly erected, self-contained drilling platforms being constructed in the offshore areas elsewhere in the country. These will be supplemented by mobile rigs.

The commitment of the petroleum companies to offshore operations is indicated by the extent of their investment in offshore exploration and development. By 1968, an estimated $7.5 billion had been spent and the annual increase in expenditures was believed to be about $2 billion annually. Less than half of the total investment is believed to have been recovered, and a representative of Shell Oil Company predicted that the cumulative monetary return would not equal the investment in offshore operations for 12 to 15 years.* Meanwhile, the escalation of drilling costs over a 10-year period due to inflation, deeper wells, and operation in deeper water was sending the per-day expenditures from $8,500 to $15,550. Cementing, logging. transportation, catering, and other costs of well operation rose 74 percent in the same period and represented about one-half of the total costs of each well.

Because drilling and operational costs are partially dependent upon both the access from shore installations and the drilling depth, the desirability of estuarine wells over deepwater operations is obvious. Yet both pose environmental problems. All offshore petroleum operations can be divided among four phases: exploration, drilling, production, and transportation. The first two phases represent imperfectly known but localized threats to environmental quality, but the second two phases can provide extended and serious threats to estuarine environments even when the petroleum operations are a significant distance beyond the estuary's merger with the sea.

(1) Exploration. The basic concept of most petroleum explorations is to identify promising rock structures by analyzing reflections of man-made shock waves. Three techniques are currently being used to produce the initial shock: electronic sparkers, gas exploders, and conventional seismic explosions. The first two are relatively inexpensive, and do not significantly affect the local biota. Their paver is weak, however, limiting the penetration of the resulting shock wave. Thus, the conventional seismic explosion, usually the electrical detonation of an explosive charge, is used extensively. Typically ranging from 5 to 25 pounds of nitro-carbonitrate, the charges are normally detonated at about 1/4-mile intervals near the water surface. Costs are comparatively high, ranging from $250 to $400 per mile, and the threat to both sea life and crews is significant.

Because of the extensive complaints by commercial fishermen, intensive studies have been performed on the effects of various types of explosions.** Explosives can generally be divided into three basic groups: low explosive, high explosive, and blasting agent. Black powder, an example of low explosive, burns progressively for a comparatively long time period with a relatively slow build-up in pressure. As a result, fish life appears to emerge unscathed but the seismographic record suffers from a lack of a distinct, sharp shock wave. Furthermore, it is considered too expensive and dangerous for crews.

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*Ibid.

**Robert L. Rulifson and Robert W. Schoning, Geophysical Offshore Oil Explorations and Associated Fishery Problems, Investigational Report No. 1, Fish Commission of Oregon (Portland: April, 1963).

Dynamite, TNT, and the majority of the military compounds comprise the high explosives. Burning is almost instantaneous, and the build-up in gas pressure is extremely fast. While the shock wave has advantageous characteristics, the materials are both expensive and dangerous to handle.

Blasting agents are considerably less expensive and are commonly available, as variants are used for fertilizer and industrial chemicals. While comparatively stable and inexpensive, their shock wave with a high-explosive primer can be compared to that of a medium-grade dynamite. Thus, blasting agents – particularly nitro-carbonitrate – have been favored for seismic operations.

When test using nitro-carbonitrate were proposed in California, the Scripps Institute of Oceanography conducted a series of tests to evaluate the possible effects on local biota.* Two test species with air bladders, pilchard and anchovies, were placed in wire cages at varying distances from the test explosion. The report concluded:

> "In the horizontal direction, out through the upper mixed layer of the ocean, the probably lethal range seems to be about 150 feet for five-pound charges, about 350 feet for ten-pound charges, and about 500 feet for twenty-five-pound charges. Vertically below the shot these limits would seem to be between 100 and 150 feet for five-pound charges, between 150 and 200 feet for ten-pound charges, and between 200 and 250 feet for twenty-five-pound charges."

Other tests have indicated that, even with an 800-pound dynamite charge, few fish were killed beyond a distance of 200 feet.** In general, results varied according to the local topography and the species of sea life involved. Extensive fish kills resulted from detonations of dynamite in a submarine canyon, suggesting that the reflection of shock waves from the sides of a deep estuary could have a similarly devasting effect. ** However, fish without air bladders – including the halibut and soles – were not usually killed or injured unless they were exceptionally close to the explosion. Also, fish with cylindrical body shapes appeared less vulnerable because of equalization of pressures on all sides of the body.

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*C. L. Hubbs, E. Paterson Schultz, and Robert Wisner, Preliminary Report on Investigations of the Effects on Caged Fishes of Underwater Nitro-Carbonitrate Explosions, unpublished manuscript of the University of California, Scripps Institute of Technology (1960).

**J.N. Gowanloch, "The Effects of Underwater Seismographic Exploration," Proceedings of the Gulf and Caribbean Fishery Institute, Second Annual Session (1950), pp 105-106.

Evaluation of the effects caused by explosions on other sea life, such as plankton, crustaceans, and shellfish, have proved difficult to perform and relatively few data exist. However, because of the incompressible fluid within these organisms, most appeared to be unharmed visibly even when collected from the immediate area of an explosion. Other tests on king crab eggs and fish eggs have similarly indicated minimal apparent damage. Some minor pollution can be caused by the absorption of the explosive's gases which, in the case of nitro-carbonitrate, include carbon monoxide, nitrous oxide, and nitric oxide. Because of the tremendous dilution that occurs immediately, this is not considered a problem by biologists.

Observations have attempted to evaluate claims that seismic explosions frighten fish and thus reduce the catches. While evidence is inconclusive, there are indications that the opposite may occur. Tuna fishermen have reported exceptionally successful catches during periods of seismic blasting and California biologists have described catching salmon with commercial trawling almost immediately after a series of explosions. *** During 1962, an otter trawl tow was made off the Columbia River with a total catch of 1,100 pounds. A series of seven seismic shots was then set off in the same area and, within 2 hours after the first tow, a second tow was performed with a yield of 800 pounds. The difference in total weight of species composition was not significant. Frequently, a slight increase in the fish population may occur because of fish arriving to feed on those previously killed. Also, an explosion apparently creates a disturbance that is attractive to certain fish species.

(2) Drilling. Three aspects of the drilling process represent threats to the estuary. First, materials are removed from the drill hole and deposited on the sea bed. Usually these are pulverized rock particles from underlying strata and are not harmful to biota. Second, drilling muds used for lubrication and maintaining pressures in the hole contain potentially dangerous chemicals. For instance, barium in the muds has sterilized top soil in experiments on land, though no published studies examine the possible extent of environmental change on the sea bottom. Most of these

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**C. L. Hubbs and A. B. Rechnitzer, "Report on Experiments Designed to Determine Effects of Underwater Explosives on Fish Life," California Fish and Game, Vol. 38, No. 3 (1952), pp 333-336.

***W. J. Baldwin, "Underwater Explosions Not Harmful to Salmon," California Fish and Game, Vol. 40, No. 1 (1954), p 77.

muds are recovered and re-used because of their value, however, and the rest are easily diluted in the ocean environment.

The third environment threat is the possible rupture of the well pressure, producing a wild well. In the restricted areas of an estuary, such an accident could be disastrous for both local flora and fauna. These occurrences, however, are highly infrequent and are being further reduced by technological advances. Since the lives of drill operators are endangered and potential losses are high, avoidance of these incidents has a high priority in petroleum operations.

(3) Production. After drilling has ceased, the danger remains of damage to the well and resulting pollution of the surrounding area with oil or natural gas – or even fire. All offshore wells, however, are required to be equipped with a storm choke which reduces the possibility of damage by a severe storm to minimal levels. During Hurricane Betsy, one well in the Gulf of Mexico did rupture below the choke but reportedly was brought under control within hours after the storm.

Increasingly, one of the severest problems in oil production along densely populated coastlines is the physical appearance of drilling or production rigs. The aesthetic aspects of oil equipment, such as platforms, tanks, and rigs, are criticized by recreationists and residents as intrusions upon the natural panorama. In parts of California, particularly Santa Barbara County, shielding structures and artificial islands for petroleum operations have been required as one aspect of measures to preserve that region's natural appearance.* With the perfection of underwater Christmas trees and maintenance equipment, the submergence of the entire production operation is becoming increasingly feasible. Another technique being used for estuaries is the slanted well with drilling rigs located on land where they can be more easily disguised.

One unique problem that can occur in an estuary is the pollution of the estuary's brackish waters with the highly saline bleed waters from the well. If uncontrolled, intrusion of this saline water can severly burn vegetation and upset the delicate salinity balances with possible long-term effects. This condition can be controlled by transporting the saline solution to open areas where disposal can occur without detriment to the ecology.

(4) Transportation. Spillage during some phase of the transportation process remains the most common form of environmental pollution from petroleum operations. Spillage from tankers cleaning their tanks has been nationally publicized and studied intensely. Similarly, the petroleum leaking from damaged barges or other vessels during transit is considered with varying results by national legislation,

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*"Steps to Guard Beauty Will Cost Producers in California," The Oil and Gas Journal (April 10, 1967), pp 56-57.

and further legal action to control this problem appears inevitable. Potential damage from a ruptured pipeline is relatively minimal because the drop in line pressure would be registered immediately on instruments at pumping installations where the line could be closed.

While spillage of petroleum in the estuary is a serious problem, it is being surpassed in extent and difficulty of control by the physical modifications being made in the estuaries to facilitate transportation, either by construction of transportation devices, particularly pipelines, or by dredging and other measures to enhance navigation. Vast changes can be made in the estuarine ecology by altering currents, salinities, silt covers, temperatures, and other underwater parameters. (See Appendix B for a more thorough description of biological effects brought by estuarine change.) The relationship between spoil operations and physical change of the estuaries can be best illustrated by recent developments in southern Louisiana and Texas. In the Northeast, spoil from dredging is already considered the predominant cause for loss in estuarine marsh area.*

Indirect Effects of Petroleum Extraction. As indicated in the previous paragraph, the indirect effects of petroleum extraction in terms of associated industrial and economic development can be more devasting to the natural condition of the estuaries than the actual recovery of the oil or natural gas. Processing plants tend to crowd the shoreline, as was sharply publicized during the 1968 elections when Santa Barbara, California, residents overturned an earlier zoning decision to allow a refinery to be constructed on a waterside site. Secondary industries, particularly the petrochemical plants, tend to emerge in response to the presence of raw materials. As markets expand, a vast array of supporting and servicing industries arise with the predictable increase in population, appropriation of estuarine area, wide-scale expansion of both industrial and domestic pollution, and, in general, extensive destruction of the natural environment and its existing benefits.

Sulfur

Significance of Estuarine Operations. Consumption of sulfur in 1967 was estimated to be about 24.9 million tons, and the annual rate of consumption increase was in the vicinity of 7 percent. Only two mines are actually situated over water, both being in the coastal zone of southern Louisiana. Freeport Sulphur's Grand Isle mine has been producing more than 1 million tons per year continuously since it opened in April, 1960. In 1968, a second mine 7 miles away began operation. However, at least three other mines in Louisiana are located on land adjacent to estuaries, and the Frasch process poses a potential pollution problem in Louisiana and Texas comparable to that of bleed water from petroleum operations.

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*John Clark, Fish and Man: Conflict in the Atlantic Estuaries, Special Publication No. 5 (Highlands, N.J.: American Littoral Society, 1967), p 12.

In the Frasch process, vast quantities of water are heated to a mining temperature of 325 F and are injected into the sulfur-bearing formation by pipeline.* Only pure sulfur emerges from the producer wells, leaving the spent water in the cavity.** To prevent a build-up of hydrostatic pressure, bleeder wells are drilled around the periphery of the deposit to release the connate waters. Even small mines eject several million gallons of bleed water per day.

Environmental Effects of Sulfur Mining. When adequate precautions are taken, the emission of bleed waters does not appear to have noticeably detrimental effects on local ecology. The principal pollutants are salt and dissolved hydrogen sulfide (270 to 1,200 mg/litter). Since the sulfide is transient and readily oxidized, adequate mixing with seawater appears to completely remove the compound. At the Offshore Grand Isle mine, this is achieved by piping 5 million gallons a day of bleed water through jets located 15 feet below the ocean surface. As a precaution, the late Dr. A. E. Hopkins at the Biloxi marine laboratory conducted a series of bioassay tests with bleed water stripped of the sulfide. Mollusks were found to tolerate concentrations of bleed water up to 50 percent. Chemically, the salt in the bleed water is identical to that found in seawater.

As in petroleum operations, probably the most drastic changes in the estuarine zone associated with sulfur mining is not in the mine's direct pollution, which is normally limited to a few hundred feet diameter from the mine site, but in the indirectly caused estuarine changes necessitated by supporting facilities. In the case of Freeport Sulphur's new Caminada mine near Grand Isle, a 9-mile insulated pipeline had to be constructed from the mine to dock facilities. Barge traffic was generated by the need to transport the elemental sulfur to the storage-shipping depot of Port Sulphur 35 miles distant. Services, including those of about 100 men constantly at the offshore mine, necessitated considerable traffic by small vessels, residential construction on shore, and the myriad commercial activities with large industrial investments. No comprehensive investigation has been made into the cumulative effects of this domestic and industrial pollution, silt deposition, and changes in physical configuration of the estuaries resulting from this development.

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*Paul D. Bybee and Frederick G. Deiler, Disposal of Sulfur Mine Effluents – How Freeport Sulfur Solved Its Effluent Problems, a paper presented at the Joint Meeting of the Coal and Industrial Division, Society of Mining Engineers of the AIME (September, 1959).

**Richard J. Lund, "Industrial Mineral Mining," Industrial Waste Water Control, C C. Fred Gurnham (ed.) (New York: Academic Press, 1965).

MINING OF MATERIALS DIRECTLY FROM ESTUARY FLOOR

Sand and Gravel

Production of sand and gravel from offshore deposits is not reported separately by the Bureau of Mines. In 1967, the total output of sand and gravel in the United States was about 905 million tons with a value of $963 million. Although the Northeast coastal area has ample offshore deposits of sand and gravel due to glacial transport and rapid streams, probably only several percent of the total U. S. production is derived from the estuarine zones. Recent surveys that have identified previously unknown deposits in the Northeast may alter the situation slightly, but each deposit will have to be evaluated by a complex balancing of cost factors.

Land operations generally require considerably lower investments in equipment, are less dependent upon weather conditions, and can be shielded from public observation. Since transportation costs frequently exceed 50% of the costs for sand and gravel, a premium exists for deposits that are readily accessible to large urban cneters. Costs in congested estuarine areas can be considerably reduced by utilizing barges for transport. One of the most prominent sand and gravel operations is at Oyster Bay, Long Island, where a floating, "ladder-type" dredge maintains navigational channels while furnishing considerable sand and gravel for sale.

As in strip-mining for coal in the upland environment, sand and gravel operations can devastate valuable salt marsh acreage by removing vegetation and leaving a sterile floor. However, unlike the upland counterpart, a strip operation in an estuary can frequently be disguised under another purpose, such as navigational channel maintenance. While an effort has been made to curb this type of operation in the Northeast, abuses are frequently difficult to detect before damage has been incurred. For example, the Connecticut Water Resources Commission has reported one flagrant example of a New York firm that applied for a permit to dig a trench 300 feet wide, 30 feet deep, and 1-1/2 miles long. Though wide enough for a battleship, the stated purpose of this channel was to provide access to a small marina site. *

Oyster Shell

An estimated 20 million tons of oyster shells are mined annually in the United States. Where only one producer is operating, the U. S. Bureau of Mines protects proprietary figures by combining the shell output with crushed stone or other mineral items. Nevertheless, the distortion is not considered significant in the overall totals

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*Louis Darling, "The Death of a Marsh: The story of Sherwood Island Marsh and Its Political Consequences," Connecticut's Coastal Marshes: A Vanishing Resource, Connecticut College, Bulletin No. 12 (1961), pp 21-27.

though outputs from individual states may be distorted. In order of descending magnitude, the primary oyster-shell mining states are: Texas, Louisiana, Alabama, Mississippi, California, Virginina, Maryland, New Jersey, and North Carolina. Use as aggregate in concrete and as road surfacing material accounts for approximately 62 percent of the shell production while another 33 percent is utilized by manufacturers of portland cement and lime. The remainder is consumed as poultry grit, mineral food, and other uses.

No comprehensive survey of oyster-shell deposits has been performed, and neither the size nor location of reserves is known. However, it is believed that the more accessible reefs have been stripped, and operations are continually becoming more marginal economically. Furthermore, some states, such as Mississippi, have become increasingly reluctant to allow oyster-shell operations within state waters because of the detrimental effect on the environment.

Objections against oyster-shell operations are usually three-fold. First, oystermen object to the removal of potential clutch material for future sets. Second, dredging releases considerable silt which can bury live reefs, and, for this reason, most states do not permit dredging near live reefs. Third, removal of oyster shell changes the configuration of the estuary's bottom, altering currents, depths, and salinities, and – in the case of reefs near the surface – removes protective shelter for other estuarine organisms. Bitter controversy has surrounded some of the oyster-shell-removal activities, such as those that have plagued the sportsmen and oystermen of Galveston Bay in recent years.*

Other

Various minerals, including diamonds, gold, rutile, and zircon, have been identified in the estuarine sands of various states. However, the economics of recovery have generally acted forcefully against any significant effort to mine the deposits. One example would be the mineral shoals off the deltas of the Chattahoochee and Apalachicola Rivers in Florida where the deeper waters have acted as sediment traps for large volumes of quartz and mineral sands. Three major shoals have been formed, and their mineral contents have been generally established by surveys. However, the beach and barrier samples have been the least attractive, assaying at about 0.10 percent mineral sands, although higher concentration in small pockets or skims have been noted. The average mineral content for the offshore sea-floor sands, on the other hand, appears to be about 0.40 percent. It appears possible that some deposits may be found where the concentration could reach 4.0 percent by weight. The probability of finding sufficient reserves to justify the capital investment needed to reach these richer sands appears too unfavorable for any potential investor today. The highly publicized deposits of phosphate rocks or sands and, particularly, the manganese modules are also found at considerably greater depths than exist in estuaries, and the economics of operating under these marine conditions have proven prohibitive.

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*Bob Eckhardt, "Death of Galveston Bay," Transactions of the Thirty-Third North American Wildlife Conference (1968), pp 79-90.

MINING OF THE ESTUARINE WATERS

Though the minerals in estuarine waters are diluted, the convenience, lower physical exposure to weather, and accessibility of estuaries have made them the favored sites for mineral and metal extraction from seawater salts. Four products form the bulk of this production: (1) common salt (sodium chloride), (2) magnesium oxide, (3) magnesium metal, and (4) bromine.

Common Salt

Of the 102 plants operated by 58 companies in the United States for production of salt, 3 are located on estuaries – San Francisco Bay, Newport Bay, and San Diego Bay – and produce salt by solar evaporation behind diked flats. The operation normally begins in the spring of the year and the crystallized salt is harvested in August and September. During 1967, about 2.7 million tons of salt valued at $17 million was recovered in these facilities. This represented about 7 percent of the total U.S. salt production; the remaining supplies were recovered from brines or mined in rock-salt deposits.

For salt production to be economical, large acreages in the estuarine area have to be maintained. Though equipment and labor costs are relatively low, this land requirement and the increase in pressures of urbanization on the estuaries appear to foreclose the possibility that future fields for solar evaporation will be opened. Environmental pollution from these fields has been nil but the aesthetic and ecological problems of allocating this acreage to the recovery of a common mineral are obvioys.

Magnesium Oxide

Magnesium oxide is used in the manufacture of refractories, ceramics, and various insulating materials. At least four plants on the Gulf of Mexico and a fifth facility in New Jersey are currently extracting magnesium for this material from sea water. During 1967, production from these plants amounted to 246,000 tons with a value of $16.4 million, representing about 30 percent of the total U.S. production. The remaining domestic supply is produced in midcontinent locations and depends upon well or lake brines and mineral deposits, such as magnesite or dolomite. Detailed investigations of the pollution or other undesirable aspects of the estuarine facilities have not been prepared.

Magnesium Metal

Magnesium metal is prepared electrolytically from magnesium chloride at the Dow Chemical Company plant in Freeport, Texas. Using seawater as a source for the magnesium chloride, the plant has been producing about 95,000 tons annually with a value of $61.5 million though the rated capacity of the facility is about 120,000 tons annually.

The demand for magnesium metal has been unexpectedly lower than forecast during the past 10 years, and further investment in this field is expected to be limited during the immediate future. Furthermore, even the proposed plants under discussion are to be located inland with sources of concentrated brines, such as the Great Salt Lake, or an entirely different process would be used. Again, no detailed examination of the environmental impact of this process upon the estuary at Freeport has been made, but the future ecological implications of this industry on the estuaries do not appear significant.

Bromine

During 1967, only two estuarine facilities were producing bromine. The Dow Chemical Company plant at Freeport, Texas, was extracting bromine as one of the products of its seawater plant, and elemental bromine was being recovered from the concentrated solutions left after solar salt evaporation at Newark, California. These two plants produced about 143.5 million pounds of bromine with a value of $34.5 million during 1967. The principal application for the chemical was in the manufacture of ethylene dibromide, an ingredient of antiknock fluids and fumigants. The recovery of bromine from seawater bitterns poses no environmental problem beyond those existing in extraction of other minerals from seawater.

CONCLUSION

In virtually every type of extractive industry associated with the estuary, the interactions between the industry and the estuarine environment are represented by direct or indirect impacts. In most cases, the direct impact, in terms of pollution and physical intrusion upon the natural ecology, could be considered serious but could also be weighed against the value of extracted minerals by simple analytical techniques. The indirect impacts are more difficult to evaluate and probably more invidious in overall effect upon the estuarine system. These are the numerous industrial, commercial, and residential activities stimulated by the extractive industries. This is particularly true for the petroleum industry which requires a complex system of pipelines, service vessels, and operating crews, and which can spawn a series of linked petrochemical industries with notoriously undesirable effects on the environment. Only a carefully designed series of regulations, such as instituted in areas of California, appear successful in controlling these indirect impacts without also terminating the economic benefits of the industrial activity.

Sand and gravel, and oyster-shell dredgers represent anomalies among the extractive industries. Both furnish low-value minerals which are absorbed directly in the urban-development process. The presence of these minerals does not cause or even stimulate significant industrial and economic development in the estuarine area, but the existence of economic development does stimulate the extractive process. Sand, gravel, and oyster-shell lime can be extracted easily, although possibly at slightly higher direct costs, from other sources. Thus, tight controls appear justifiable where estuarine values in terms of fisheries and public recreation can be compared to the one-time exploitation by private parties. Unfortunately, no clear, inflexible rule can replace the current case-by-case examination of mineral values versus biological productivity and recreational use.

APPENDIX G

ECONOMIC ASSESSMENT OF ESTUARINE POLLUTION

Neil F. Drobny and Syed Qasim

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APPENDIX G

ECONOMIC ASSESSMENT OF ESTUARINE POLLUTION

by

Neil F. Drobny and Syed Qasim

SUMMARY

Scope. The natural capacity of estuaries (1) to assimilate organic (BOD) wastes and (2) to provide natural cooling for thermal discharges can be quantitatively estimated, but available information is insufficient to establish the economic consequences of pollutant discharges upon marine ecology, fish and wildlife, recreation, port navigation, and transportation. Thus, this analysis has attempted to assess only the economic implications in terms of the hypothetical waste treatment required to raise the quality of existing effluent to an acceptable standard. The actual costs being incurred by society is not meeting these and other standards in the discharge of liquid wastes into estuaries are discussed only qualitatively.

Organic (BOD) Wastes. Quantitative estimates of the economic worth of the natural assimilative capacity of estuaries for organic (BOD) loadings were based upon the cost of waste treatment which could be saved by tolerating incremental decreases of 1/mg/ℓ in the minimum dissolved-oxygen concentration in the estuary. Analyses were conducted for five estuaries having a total area of 116,670 acres, and the total economic contribution of the assimilative capacity of these waters was estimated to be $5,903,000 per year for each mg/ℓ gained in the minimum dissolved oxygen level. Sufficient data were not available to generate an assessment of the national contribution. A projection solely on the basis of estuarine acreage is not justified because the estuaries analyzed are heavily industrialized and their combined waste assimilative capacity is not truly representative. This is true because for an estuarine assimilative capacity to possess economic value, a waste loading must be present. Projections based on a combined measure of population and industrial base, which are in turn a measure of waste loadings, would be one way of extending the assessment generated in this study.

Thermal Discharges. Quantitative estimates of the economic worth of natural cooling capacity of estuaries were based upon the cooling costs which could be avoided by tolerating incremental increases of 0.1 degree Fahrenheit in the maximum downstream temperature of the estuary resulting from a 10^{10} Btu/day point loading. Based on analyses of three estuaries having surface area of 31,870 acres, the average annual economic value for this cooling capability was estimated to be about $34,700.

Because of the many simplifying assumptions employed to generate these estimates, of course, these values should be interpreted only as gross indications and not as firm figures.

INTRODUCTION

Significance of Waste Assimilation

Of the world's ten largest metropolitan areas, seven have developed upon the shores of estuaries. Today, one-third of America's population lives and works in the estuarine zones. Through tradition, convenience, and simple economics, the liquid and, to a lesser extent, the solid wastes of these urban complexes have been shunted to the estuaries with the assumption that the estuaries' natural assimilative capacity would rid the communities of further nuisance. In many cases, this assumption has been partially correct. But estuaries vary tremendously in shape, size, physical, and hydrological features. The ability of many estuaries, both to maintain acceptable water quality and to assimilate more wastes, has been grossly exceeded. Obviously, the cost of maintaining water quality by treatment must be compared with the costs of allowing the quality standards to be bleached further. The objective of this analysis is to define the dimensions of this trade-off between quality and treatment.

Methodology

The only information sources and predictive techniques employed in this study were those described in the literature. No experimental work, sampling programs, or model development studies were conducted. The rationale employed was to assign an economic benefit to waste assimilative capacity equal to the costs which would be incurred to achieve an incremental increase in the level of water quality through waste treatment in on-shore waste-treatment plants. Wherever information was available, the negative benefits imposed upon fish and wildlife, recreation, and other estuarine resources have been noted.

A separate question not considered in this report is whether or not the natural assimilative capacity should be exceeded. This is a policy question, not a technical one. Technical studies outlined in this appendix, however, provide a basis for assessing the economic implications and consequences of the policy decisions related to this question.

As previously indicated, detailed analyses have been restricted to the assimilation of organic wastes (Biochemical Oxygen Demand) and of waste heat loadings. Although other waste-material parameters, such as phosphorus and nitrogen, coliform bacteria, and toxicity, can be conceived and identified, BOD and waste heat were selected because (1) the capacity to assimilate these two waste streams appears to contribute the major portion of the economic value of the estuaries and (2) the state of the art allowing us to predict the response of an estuarine environment to various loadings is particularly developed for these two parameters.

This more advanced state of the art, though, is only relative to the other parameters. As G.T. Orlob stated at a recent technical meeting, estuaries are - except for the oceans themselves - the most difficult of the water environments to analyze.* Even prediction of estuarine water temperature as a function of waste-heat loads is not as developed as models for response of dissolved oxygen in the estuarine waters as a function of BOD loadings. Nevertheless, order-of-magnitude estimates are possible with the existing predictive techniques.

ASSIMILATION OF BOD LOADINGS

Existing DO/BOD Models

Because of the significant physical, chemical, and ecological differences between all estuaries, quantitative discussion of waste assimilative capacity must be approached on an estuary-by-estuary basis. Existing research and engineering studies have been concerned with the development of models for predicting the dissolved oxygen response of a given estuary, or class of estuaries, and have been based on extension of the work by Streeter and Phelps on natural purification in the Ohio River.**

O'Connor developed a steady-state model for predicting the dissolved oxygen profile that considered the effects of displacement by land runoff, longitudinal diffusion, the concentration of the organic material, rate of oxidation of organic material, and the resulting rate of reaeration.*** The model was confirmed by field data from estuarine surveys of the Delaware and James Rivers. O'Connor developed a similar, but less general, model for the Hudson River and New York Harbor, and generally close agreement between theoretical prediction and observed values was noted.**** Thomann developed a model for describing the time variation of dissolved oxygen in a finite number of sections of an estuary; a frequency-response technique is employed and dissolved-oxygen response equations resulting from imposition of general input forcing functions are derived.* The model results in a system of differential equations which require computer solution. Thomann and Sovel extended Thomann's model to provide a means for determining optimum utilization of funds for waste treatment and water-quality management in an estuary.** O'Connor developed a general model more refined than his previous one for handling the distribution of nonconservation substances in estuaries.***

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*G.T.Orlob, statement before the American Water Resources Association Symposium on Analysis of Water Resource Systems (July 3, 1968), in Denver, Colorado.

**H.W. Streeter and E.P. Phelps, A Study of the Pollution and Natural Purification of the Ohio River, Public Health Bulletin No. 46, U.S. Department of Health, Education and Welfare, Public Health Service (Washington: 1925).

***Donald J. O'Connor, "Oxygen Balance of an Estuary", Journal of the Sanitary Engineering Division, American Society of Civil Engineers 86-SA3 (May, 1960) pp 35-55.

****Donald J. O'Connor, "Organic Pollution of New York Harbor, Theoretical Considerations", Journal of the Water Pollution Control Federation, 34-6 (September, 1962), pp 905-919.

Analytical Approach for Predicting Environmental Response

Because of the relative simplicity of the calculations involved and because the objective of this investigation was to generate informative estimates as opposed to decision criteria, O'Connor's original mathematical model for investigating the oxygen balance in an estuary was selected for making the estimates in this study.**** This model describes the oxygen balance in an estuary as a function of land runoff, longitudinal diffusion, tidal action, atmospheric reaeration, and deoxygenation as a result of BOD decay. To generate the estimates outlined below, this model was combined with selected data and other information sources for the Delaware River, Potomac River, James River, East River, and Hudson River estuaries. In each case, the assimilative capacity for BOD loadings was assessed by calculating the response of the minimum dissolved oxygen level in the estuary to various levels of BOD removal. The economic implications were then calculated from estimated costs of BOD removal at various types of treatment plants.

THE DELAWARE ESTUARY

Background

The Delaware Estuary is defined as the 86 miles of waterway from Trenton, New Jersey, to Liston Point, Delaware, where Delaware Bay commences (See Figure G-1). While municipal waste-treatment plants serve the majority of the population, eight plants

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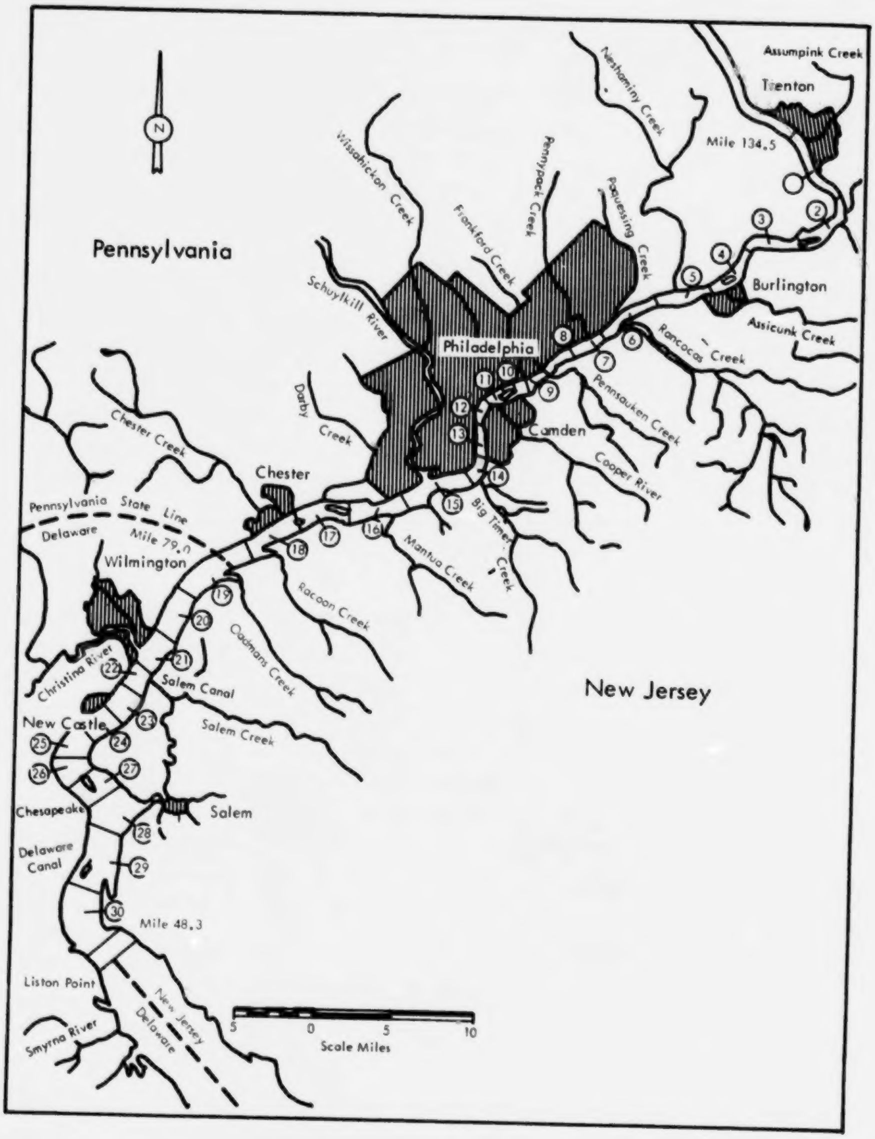
*R.V. Thomann, "Mathematical Model for Dissolved Oxygen", Journal of the Sanitary Engineering Division, American Society of Civil Engineers 89-SA5 (October, 1963), pp 1-30.

**R.V. Thomann and N.J. Sovel, "Estuarine Water Quality Management and Forecasting", Journal of the Sanitary Engineering Division, American Society of Civil Engineers, 90-SA5 (October, 1964), pp 9-36.

***D.J. O'Connor, "Estuarine Distribution of Non-Conservation Substances", Journal of the Sanitary Engineering Division, American Society of Civil Engineers, 91-SA1 (February, 1965).

****For a summary of the model, see "Notes to Appendix G" at the end of this paper.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Burlington
Assicunk Creek
Philadelphia
Rancocas Creek
Pennsauken Creek
Darby Creek
Chester Creek
Camden
Cooper River
Chester
Big Timber Creek
Pennsylvania State Line
Delaware Mile 79.0
Wilmington
Mantua Creek
Racoon Creek
Oldmans Creek
Christina River
Salem Canal
Salem Creek
New Jersey
New Castle
Chesapeake
Salem
Delaware Canal
Mile 48.3
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Source: Federal Water Pollution Control Administration, U.S. Department of the Interior, Delaware Estuary Comprehensive Study, Preliminary Report and Findings (Philadelphia: July, 1966)

Figure G-1. The Delaware Estuary Showing the Thirty Sections Being Studied by the Federal Water Pollution Control Administration contribute over 90 percent of the area's discharged municipal oxygen-demanding load. Total estimated waste loadings in terms of carbonaceous oxygen demand before treatment are described in Table G-1.*

TABLE G-1. ESTIMATED BOD LOADINGS (BEFORE TREATMENT) IN THE DELAWARE ESTUARY

Year	Carbonaceous BOD, lb/day		
	Industrial	Municipal	Total
1964	700,000	1,200,000	1,900,000
1975	1,200,000	2,800,000	4,000,000
2010	4,600,000	6,100,000	10,700,000

Source: Federal Water Pollution Control Administration, U.S. Department of the Interior, Delaware Estuary Comprehensive Study, Preliminary Report and Findings (Philadelphia: July, 1966).

The total carbonaceous oxygen-demanding waste load actually discharged after treatment during 1964 was estimated to be about 1,030,000 lb/day, with 650,000 lb/day from municipal sources and 370,000 lb/day attributed to industries. The degree of treatment provided by various facilities averaged about 47 percent removal of carbonaceous BOD for the estuary as a whole. Additional oxygen demand resulted from the discharge of about 600,000 lb/day of nitrogenous material from both municipal and industrial sources. Because of these loadings, water quality from Torresdale, Pennsylvania, to below the Pennsylvania-Delaware state line was exceptionally low, and anaerobic conditions developed frequently, especially during the summer months. Offensive solids, floating materials and miscellaneous flotsam seriously degraded the aesthetic quality of the estuary.

FWPCA Estimates

The FWPCA Delaware Comprehensive Study provided a detailed estimate of the economic value that could be assigned to the estuary's natural assimilative capacity. Estimated costs were generated for achieving five levels, termed "objective sets", of water quality in the estuary. The dissolved oxygen objectives, allowable waste loadings, total estimated costs, and estimated benefits - mostly recreational - for the respective objectives sets are summarized in Table G-2.

It should be noted, of course, that about sixteen parameters other than dissolved oxygen can be used to specify water quality associated with objective set. Dissolved

TABLE G-2. DELAWARE ESTUARY WATER QUALITY OBJECTIVE SETS

Objective Set	Dissolved Oxygen, minimum summer(a) average, mg/1	Allowable Carbonaceous Oxygen-Demand Loadings, lb BOD/day	Costs(b,c), millions of dollars	Estimated(d) Incremental Benefits Over Objective Set V millions of dollars	Net Cost or Benefit*, millions of dollars
(1)	(2)	(3)	(4)	(5)	(6)
I	4.5	100,000	460	255	205C
II	4.0	185,000	250	230	20C
III	3.0	485,000	125	220	95B
IV	2.5	595,000	95	200	105B
V (present conditions)	1.0	950,000	30	0	30C

Source: Federal Water Pollution Control Administration, U.S. Department of the Interior, Delaware Estuary Comprehensive Study, Preliminary Report and Findings (Philadelphia: July 1966).

(a) Will occur south of Philadelphia.
(b) Values given represent means of ranges given by source cited below.
(c) 1964 present worth of amortized capital and maintenance and operating costs for 25 years.
(d) Primarily recreational but also includes commercial fishing and negative benefits to industrial water uses to account for corrosion effects at higher dissolved oxygen levels.
*C = Cost-Column 4 minus Column 5.
B - Benefit=Column 5 minus Column 4.

oxygen was selected as a basis for comparison because of its direct relationship to waste loadings as measured by BOD. One measure of the economic benefit attributable to natural assimilative capacity can be made by comparing Objective Set II to Objective Set I. For an increase of 85,000 lb BOD/day in allowable loading, approximately $185 million, or $2170 per lb BOD/day discharged, may be saved. Selection of Objective Set III over II would permit the discharge of an additional 300,000 lb BOD/day, with an incremental saving of $115 million or $393/lb of BOD discharged.

O'Connor Model Estimates

To simplify the calculations involved in applying the O'Connor model to the Delaware Estuary, the thirty sections employed in the comprehensive FWPCA study were combined into five extended sections, and all waste floatings were assumed to occur at the mid-point of each section as indicated in Table G-3. It should be noted that grouping the waste loadings into five point sources will yield somewhat lower values of dissolved oxygen than a distributed loading. The effect of this difference is not considered to be significant, however, for the purpose of this analysis.

TABLE G-3. IDEALIZED WASTE LOADINGS IN DELAWARE ESTUARY

Assumed Segment of Loading	Component Segments	Total Waste Load, lb BOD/day
4	1-6	18,000
9	7-11	136,000
13	12-14	309,000
18	15-20	327,000
24	21-30	226,000
		1,016,000

Source: Federal Water Pollution Control Administration, U.S. Department of the Interior, Delaware Estuary Comprehensive Study, Preliminary Report and Findings (Philadelphia: July 1966).

Data in the FWPCA report indicated that the most critical section of the estuary in terms of dissolved oxygen levels was Section 15, just south of Philadelphia. Using the waste loading summarized in Table G-3, as well as other data presented in the FWPCA report and by O'Connor, Figure G-2 illustrates the idealized effect of BOD removal (equal percent removal assumed to occur at all points of loading) on the minimum dissolved oxygen in the estuary.

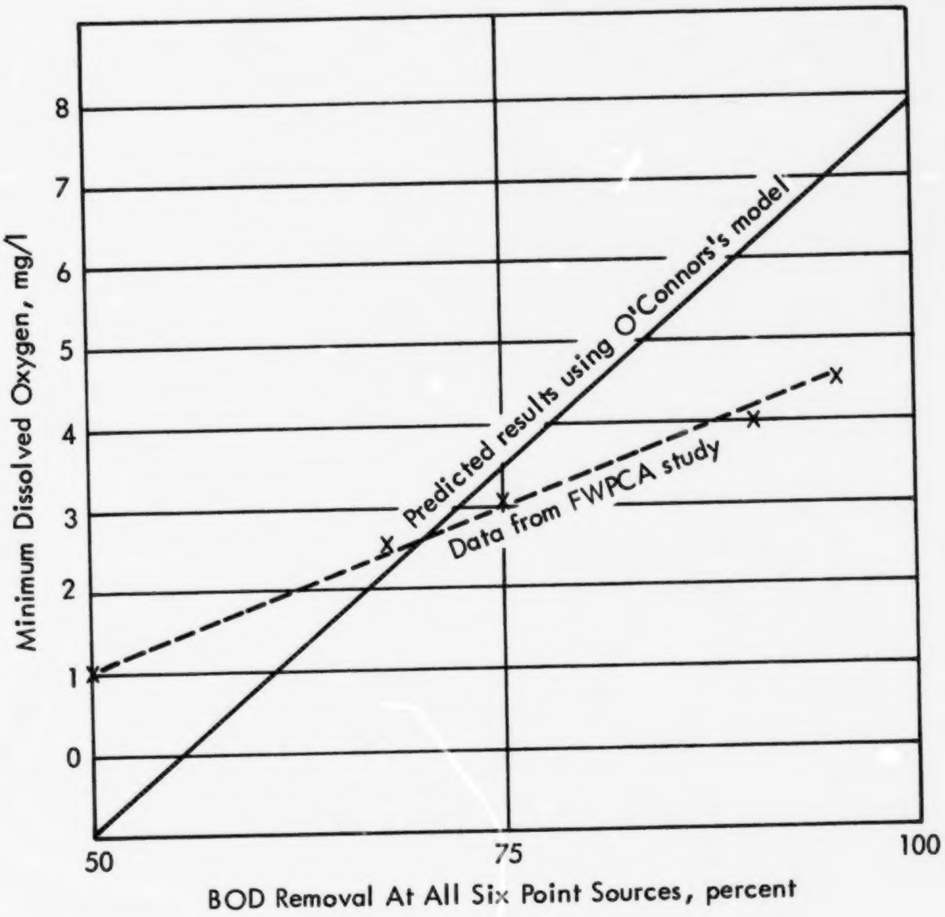

Figure G-2. Idealized Response of Minimum Dissolved Oxygen in the Delaware Estuary to Bod Loading

The dissolved oxygen response as predicted by the model agrees satisfactorily with the observed condition. The FWPCA report describes the averaged dissolved oxygen in Section 15 during the summer of 1964 as 0.7 mg/ℓ., but also indicates that periods of anaerobic conditions have been noted. The model predicts an anaerobic condition (i.e., minus 0.9 mg/ℓ). The model also predicts that at 100 percent BOD removal, the dissolved oxygen should rise to 8 mg/ℓ; the saturation value described by O'Connor is 8.1 mg/ℓ.

From Figure G-2, it can be determined that each incremental 1 mg/ℓ increase in the minimum dissolved oxygen requires removal of an additional 5 percent of the total BOD load, or about 100,000 lb/day. For comparison purposes, data on allowable BOD loading from the FWPCA report were correlated with the percent removal based on the existing load of 1,900,000 lb/day, as described in Table G-4. The dotted line in Figure G-2 depicts these data graphically. The flatness of this curve, which indicates that about 300,000 pounds of BOD per day must be removed to achieve a 1 mg/ℓ increase in a minimum dissolved oxygen, is attributed to the large benthal and nitrogenous oxygen demands, which together amount to about 800,000 lb/day and which are not taken into account in O'Connor's model. Thus, it appears that the results predicted by O'Connor's model for the Delaware Estuary are low by about a factor of 3 when compared with the results of the more sophisticated analyses conducted for the FWPCA.

TABLE G-4. BOD REMOVALS REQUIRED TO ACHIEVE DELAWARE ESTUARY WATER-QUALITY OBJECTIVE SETS

Objective Set	Minimum Dissolved Oxygen, mg/ℓ	BOD Loadings	
		(Lb/Day)	Percent Removal(a)
I	4.5	100,000	95
II	4.0	185,000	90
III	3.0	485,000	75
IV	2.5	595,000	68
V	1.0	950,000	50

Source: Federal Water Pollution Control Administration, U.S. Department of the Interior, Delaware Estuary Comprehensive Study, Preliminary Report and Findings (Philadelphia: July 1966).

(a) Based on "present" 1964 untreated loadings of 1,900,000 lb/day.

POTOMAC RIVER ESTUARY

Background

The Potomac Estuary extends from Little Falls to the Chesapeake Bay and is subject to a wide variety of regional waste loadings. The upper estuary extending 25.8

miles to Hollowing Point is the most critical section and will provide the primary focus for the following analyses (see Figure G-3). To date, the natural assimilative capacity of the receiving waters has been adequate to eliminate any measurable water-quality degradation before the upper estuary near Washington is reached.

Waste loads into the upper estuary are about 140,000 pounds of the BOD per day, which is eight times the assimilative capacity required to maintain a dissolved oxyben level of 5 mg/ℓ.* Specific sources of pollution are listed in Table G-5. The overall combined BOD removal of the five major treatment plants has been estimated at about 50 percent, suggesting that the raw waste loadings prior to treatment are approximately 280,000 lb BOD/day.

Estimated BOD Removal Requirements

Figure G-4 indicates the removals of 5-day BOD required to achieve various minimum dissolved oxygen levels at the Woodrow Wilson Bridge south of Washington in 1965, originally reported by Aalto.** From the slope of the graph, it may be determined that an increase in each additional 1 mg/ℓ in the minimum dissolved oxygen will require removal of 10 percent of the BOD load. With total waste generated in the estuary region estimated at 280,000 lb/day, each 1 mg/ℓ increase in dissolved oxygen would require removal of 28,000 pounds of BOD per day.

JAMES RIVER ESTUARY

Background

The James River Estuary (Figure G-5) begins at Richmond, Virginia; the major waste loadings occur at Richmond and at Hopewell, a community 20 miles downstream from Richmond. The BOD loading from Richmond is approximately 50,000 lb/day,

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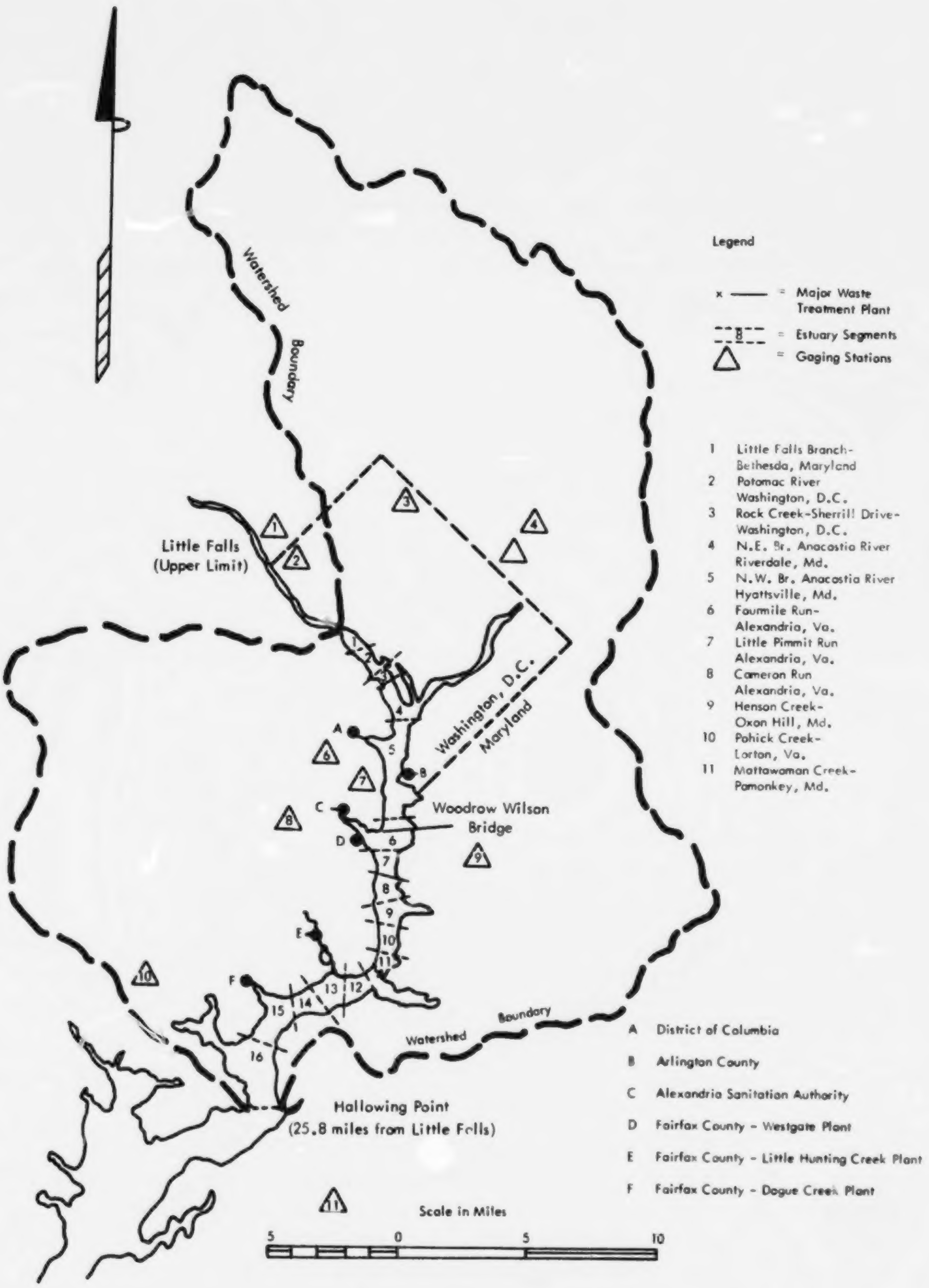
*Data sources are:

D. Aalto, "The Potomac Estuary - Statistics and Projections", Paper presented at the winter meeting of the Interstate Commission on the Potomac River Basin, Fredericksburg, Virginia (February 29, 1968).

L. J. Hetling, A Mathematical Model for the Potomac River - What It Has Done and What It Can Do, Paper presented at the fall meeting of the Interstate Commission on the Potomac River Basin, St. Mary's City, Maryland (September 22, 1966).

**Aalto, Johan A., The Potomac Estuary - Statistics and Projections.


Legend
x —— = Major Waste Treatment Plant
8 = Estuary Segments
△ = Gaging Stations
1 Little Falls Branch-Bethesda, Maryland
2 Potomac River Washington, D.C.
3 Rock Creek-Sherrill Drive-Washington, D.C.
4 N.E. Br. Anacostia River Riverdale, Md.
5 N.W. Br. Anacostia River Hyattsville, Md.
6 Fourmile Run-Alexandria, Va.
7 Little Pimmit Run Alexandria, Va.
8 Cameron Run Alexandria, Va.
9 Henson Creek-Oxon Hill, Md.
10 Pohick Creek-Lorton, Va.
11 Mattawoman Creek-Pomonkey, Md.
A District of Columbia
B Arlington County
C Alexandria Sanitation Authority
D Fairfax County - Westgate Plant
E Fairfax County - Little Hunting Creek Plant
F Fairfax County - Dogue Creek Plant
Watershed Boundary
Little Falls (Upper Limit)
Washington, D.C.
Maryland
Woodrow Wilson Bridge
Hallowing Point (25.8 miles from Little Falls)
Scale in Miles
5
0
5
10

Source: Hetling, L. J., and R. L. O'Connell, A Study of Tidal Dispersion in the Potomac River, C-SRBP Technical Paper No. 7, FWPCA, Region III (undated)

Figure G-3. The Upper Potomac Estuary Indicating the FWPCA Estuary Segments

TABLE G-5. SOURCES OF POLLUTION IN THE UPPER POTOMAC ESTUARY

Plant Source	Percent of Total BOD Contributed
District of Columbia WPC plant	72
Arlington sewage treatment plant	16
Fairfax County Westgate sewage treatment plant	7
City of Alexandria sewage treatment plant	4
Fairfax County's Dogue Creeke and Little Hunting Creek plants	1

Source: Aalto, Johan A., "The Potomac Estuary - Statistics and Projections", Paper presented at the winter meeting of the Interstate Commission on the Potomac River Basin at Fredericksburg, Virginia, on February 29, 1968.

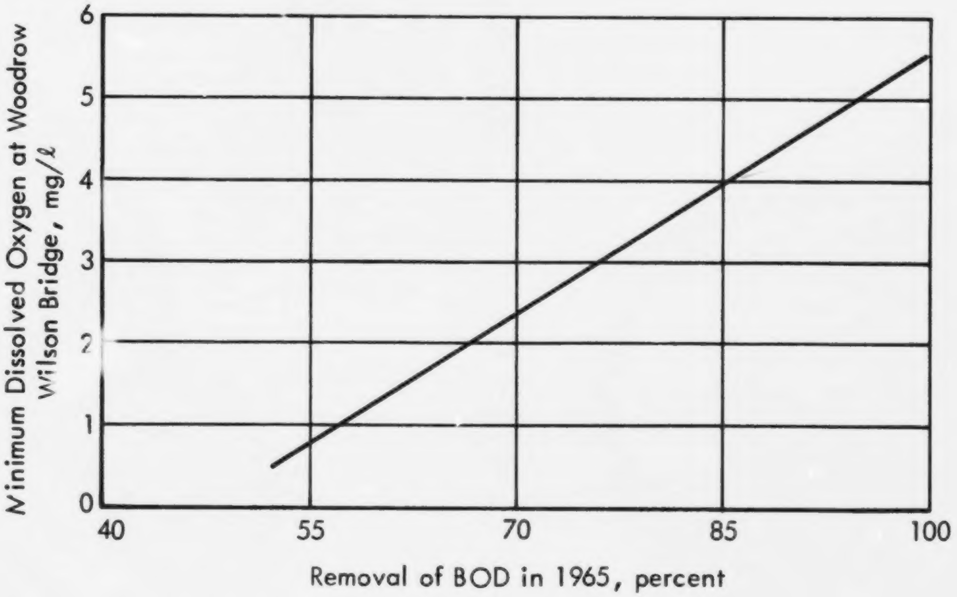
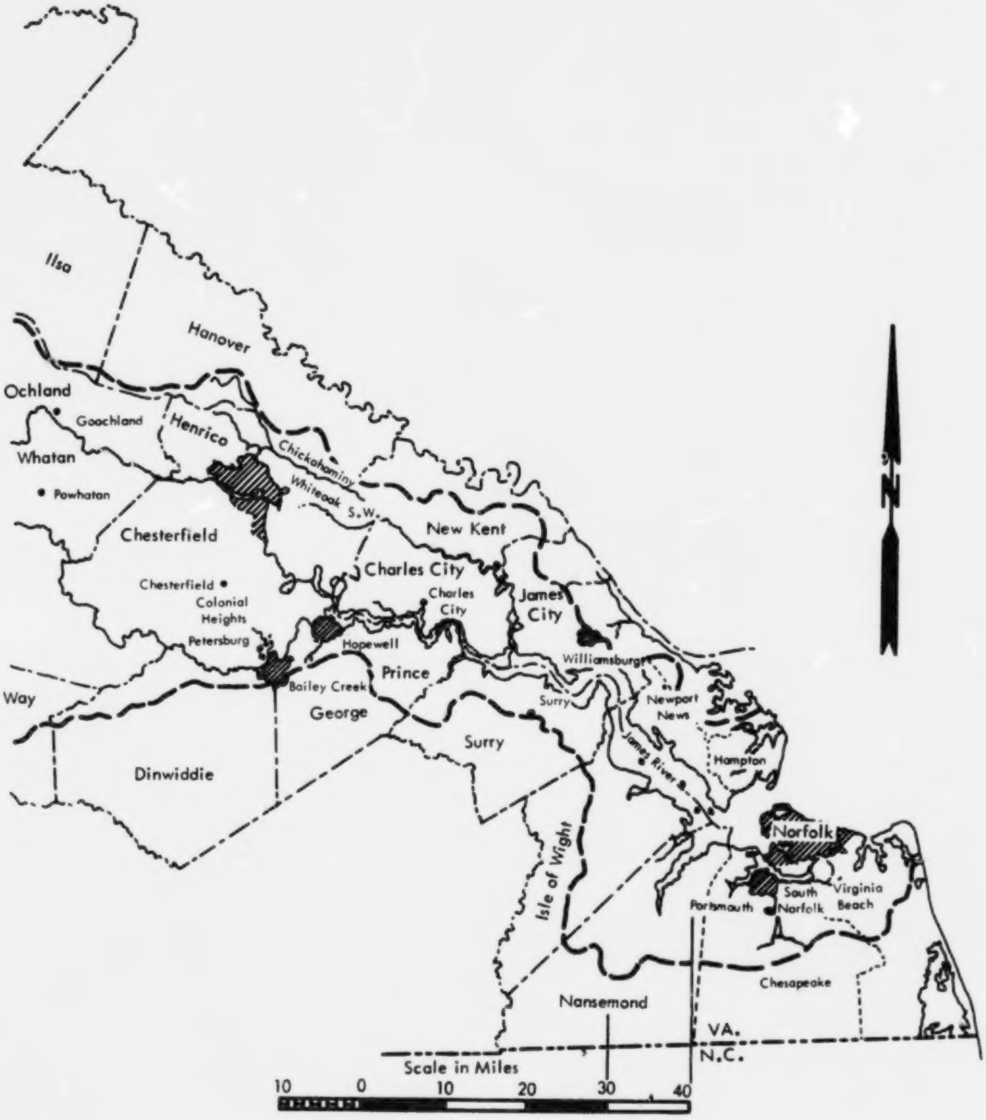


Figure G-4. Idealized Response of Minimum Dissolved Oxygen in the Upper Potomac Estuary to Bod Loading (1965 Conditions)


Ilsa
Hanover
Ochland
Goochland
Henrico
Whatan
Powhatan
Chickahominy
Whiteoak S.W.
Chesterfield
New Kent
Chesterfield
Colonial Heights
Petersburg
Charles City
Charles City
James City
Hopewell
Williamsburg
Prince
Bailey Creek
George
Way
Surry
Newport News
Surry
James River
Hampton
Dinwiddie
Norfolk
Isle of Wight
South Norfolk
Virginia Beach
Portsmouth
Chesapeake
Nansemond
VA.
N.C.
N
Scale in Miles
10
0
10
20
30
40

Source: Federal Water Pollution Control Administration, U.S. Department of the Interior, Water Quality and Pollution Control Study-James River Basin, CB-SRBP Working Document No. 14, Middle Atlantic Region (June, 1967).

Figure G-5. The James River and its Upper Estuary while Hopewell's is approximately 175,000 lb/day.* Overall BOD removal in the upper estuary is estimated at about 42 percent, so the raw BOD loading is about 390,000 lb/day.

Estimated BOD Removal Requirements

Figure G-6 indicates the predicted response of the minimum dissolved-oxygen level in the estuary as a function of equivalent levels of BOD removal at both Richmond and Hopewell. The minimum dissolved-oxygen level was calculated to occur about 32 miles downstream of Richmond; this compares to about 27 miles for the field data published by O'Connor.

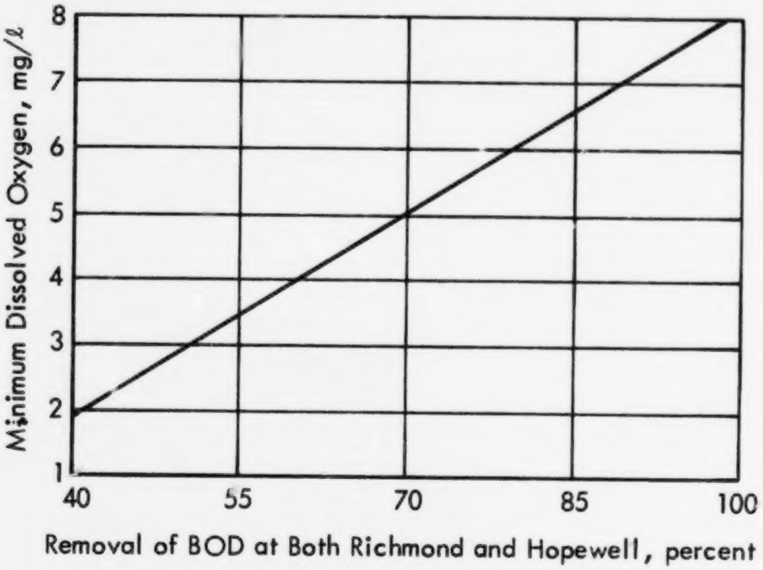


Figure G-6. Idealized Response of Minimum Dissolved Oxygen in the Upper James Estuary to Bod Loading (1965 Conditions)

At 42 percent removal of the total load at both Richmond and Hopewell, the minimum dissolved oxygen is calculated at 2.2 mg/ℓ. This is compared to 2.8 mg/ℓ for the field data published by O'Connor, the discrepancy arising from the slightly higher degree of treatment currently being provided at Hopewell compared to Richmond. From Figure 6, it may be determined that each additional 1 mg/ℓ increase in the minimum dissolved oxygen concentration requires removal of an additional 10 percent of the BOD loadings at Richmond and Hopewell, or an additional 39,000 lb/day.

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*Federal Water Pollution Control Administration, U.S. Department of the Interior, Water Quality and Pollution Control Study - James River Basin, CB-SRBP Working Document No. 14, Middle Atlantic Region (June, 1967).

O'Connor, Donald J., "Oxygen Balance of an Estuary".

O'Connor, Donald J., "Estuarine Distribution of Non-Conservation Substances".

EAST RIVER ESTUARY

Background

The East River is essentially a long, narrow strait connecting Upper New York Harbor with Long Island Sound (see Figure G-7). The Harlem River joins the East River approximately midway between these points. There is essentially no fresh water flow to the East River, except for waste water and periodic storm overflows. The large quantities of organic matter in the waste flows cause significant depletions of dissolved oxygen, particularly at the end of the summer and early fall when water temperatures are high. The East River Survey Stations of the New York City Department of Public Works are described by O'Connor, and the assembled data indicate that the concentration of BOD is fairly constant over the summer.* Low fresh-water flow and consistent waste-water discharge at various locations cause a steady-state condition, and only seasonal temperature variations have a significant effect upon dissolved oxygen.

The BOD input data from existing treatment plants for July, 1960, as presented by O'Connor are given below.

Treated Sources	Units
Ward's Island	37,600 lb/day
Bowery Bay	50,000
Hunt Point	14,700
Tallman Island	5,600
Newtown Creek	30,600
Harlem River	6,600
Total	145,100 lb/day

Untreated Sources	Units
Manhattan	99,400 lb/day
Brooklyn-Queens	93,000
Storm overflow	10,000
Total	202,400 lb/day

Assuming that the treatment plants provide an overall average BOD removal of 60 percent, the before-treatment loading of the plants is estimated to be about 363,000 lb/day. Thus, the total raw load is approximately 565,000 lb/day. The weighted overall removal from all sources, treated plus untreated, is calculated to be about 40 percent.

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*Donald J O'Connor, "An Analysis of the Dissolved Oxygen Distribution in the East River", Journal of the Water Pollution Control Federation, 38-11 (1966), pp 1813-1830.

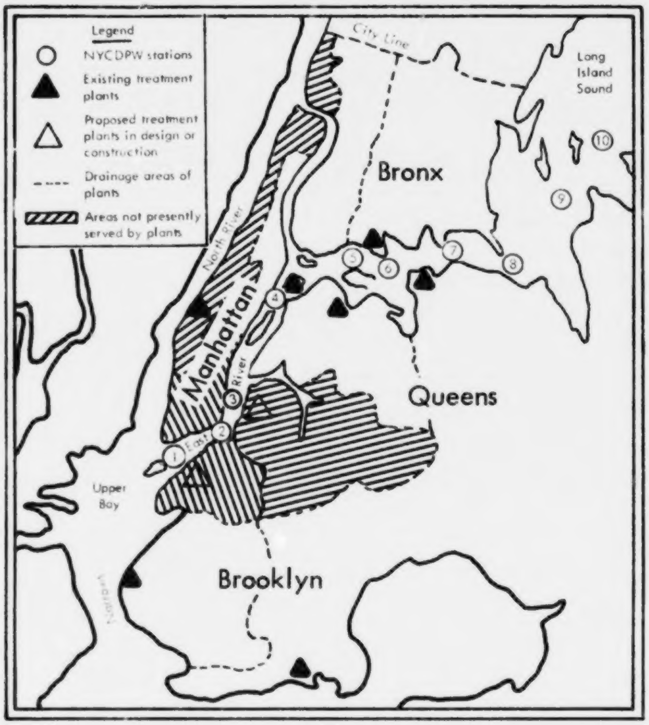
Legend
NYCDPW stations
Existing treatment plants
Proposed treatment plants in design or construction
Drainage areas of plants
Areas not presently served by plants
City Line
Long Island Sound
Bronx
North River
Manhattan
East River
Queens
Upper Bay
Narrows
Brooklyn
1
2
3
4
5
6
7
8
9
10

Figure G-7. East River Estuary*

Estimated BOD Removal Requirements

Data presented by O'Connor indicate that the minimum dissolved oxygen in the East River occurs approximately 4.2 miles north of the Battery. Use of O'Connor's data and the model described earlier yield the effect of BOD removal on the minimum dissolved-oxygen concentration described by Figure G-8. Calculations indicate that pollutant loadings delivered by the Hudson River do not materially affect dissolved oxygen levels in the East River because of the dilution available in the upper bay. Based on the curve in Figure G-8, it is calculated that each incremental 1 mg/ℓ increase in the minimum dissolved oxygen requires removal of an additional 9 percent of the total load, or about 51,000 lb/day.

HUDSON RIVER ESTUARY

Background

The critical reach of the Hudson Estuary in terms of waste loadings is the lower 24-mile waterway from the New York City line to the Narrows (See Figure G-9). The minimum dissolved-oxygen concentration occurs at the Battery.

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*Donald J. O'Connor, "An Analysis of the Dissolved Oxygen Distribution in the East River," *Journal of the Water Pollution Control Federation*, 38-11 (1966), pp 1813-1830. Reprinted with permission from *Journal of the Water Pollution Control Federation* 38-11, pp. 1813-1830, November 1966, Washington, D.C. 20016.

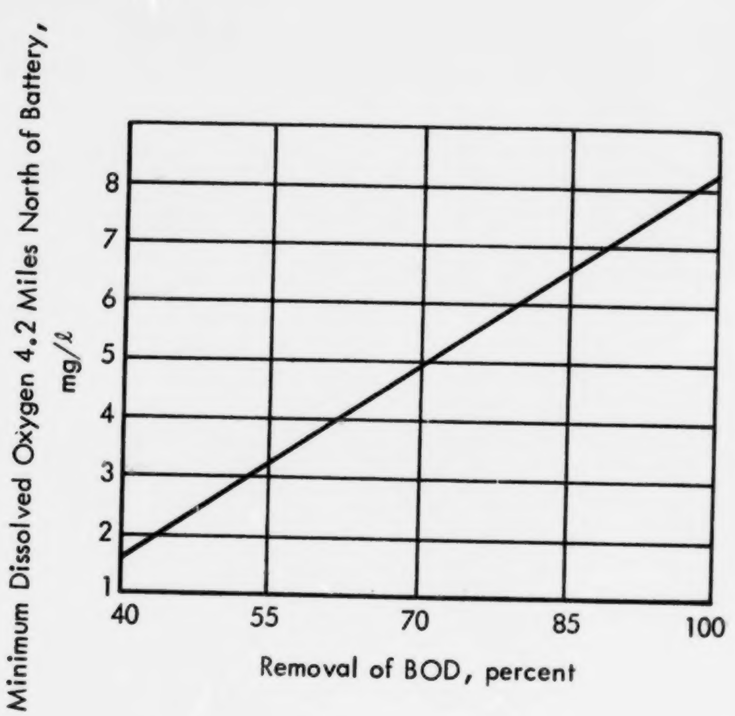

Figure G-8. Idealized Response of Minimum Dissolved Oxygen in the East River to Bod Loading

Data supplied by O'Connor indicate that the waste loading reaches 525,000 lb/day.* In order to simplify the analysis of the effect of BOD removal on minimum dissolved oxygen, it was assumed that the entire waste loading to the Hudson River between the Battery and the city limits occurs at the midpoint, about 9 miles above the Battery.

Estimated BOD Removal Requirements

Based on O'Connor's model, the effect of BOD removal on the dissolved oxygen concentration at the Battery is described by Figure G-10. The total BOD load to the River is 525,000 lb/day. Assuming that this represents 50 percent removal, the total raw load is about 1 million lb/day. From the slope of the curve in Figure G-10, each incremental 1 mg/ℓ increase in the minimum dissolved oxygen level appears to require removal of an additional 14 percent of the waste loading, or about 187,000 lb/day.

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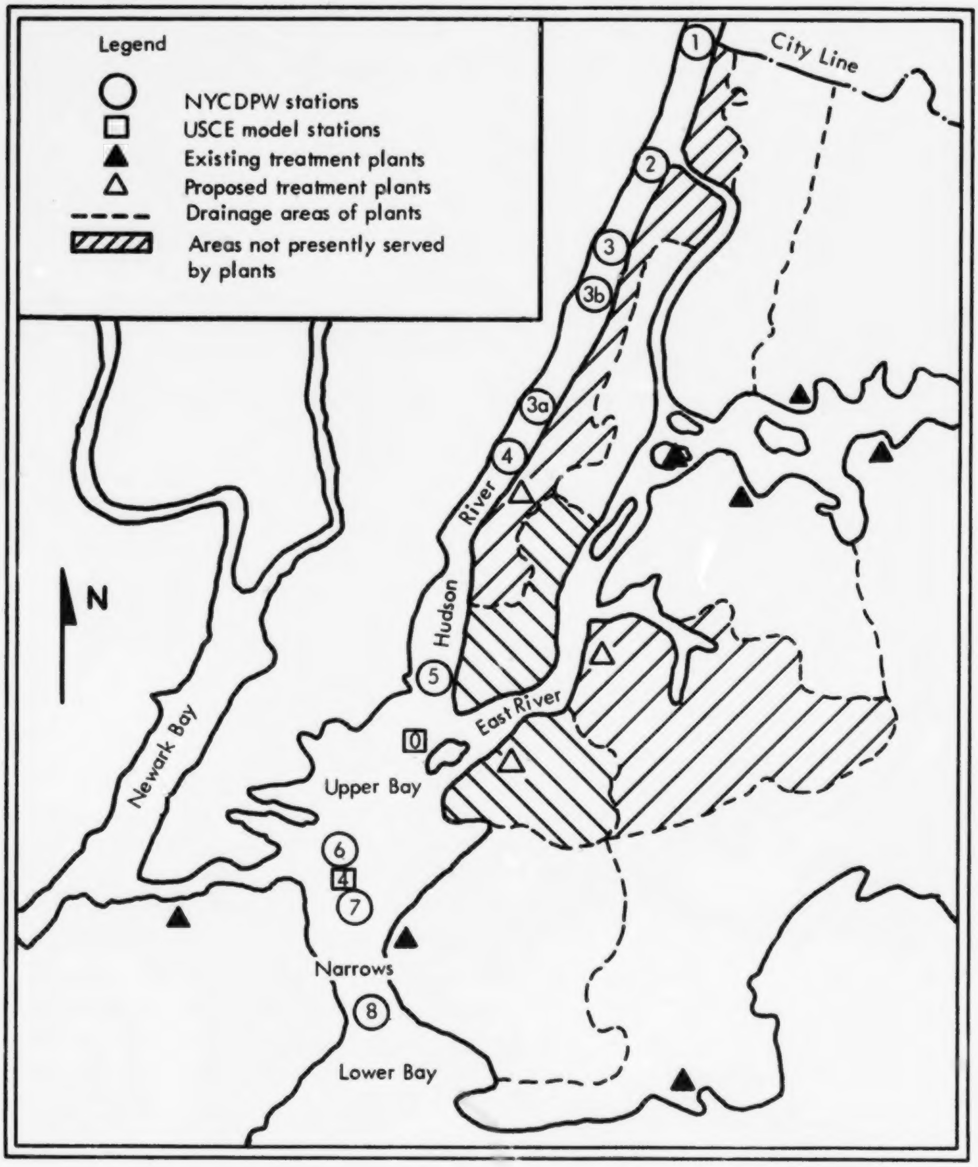
*Donald J. O'Connor, "Organic Pollution of the New York Harbor - Theoretical Considerations", Journal of the Water Pollution Control Federation, 34-9 (September, 1962), pp 905-919.


Legend
○ NYCDPW stations
□ USCE model stations
▲ Existing treatment plants
△ Proposed treatment plants
- - - - Drainage areas of plants
▨ Areas not presently served by plants
City Line
N
1
2
3
3b
3a
4
Hudson River
5
East River
0
Upper Bay
Newark Bay
6
4
7
Narrows
8
Lower Bay

Source: O'Connor, Donald J., "Organize Pollution of the New York Harbor-Theoretical Considerations", *Journal of the Water Pollution Control Federation*, 34-9 (September, 1962), pp. 905-919. Reprinted with permission from *Journal of the Water Pollution Control Federation*, 34-9, pp. 905-919, September 1962, Washington, D.C. 20016.

Figure G-9. Hudson River Estuary

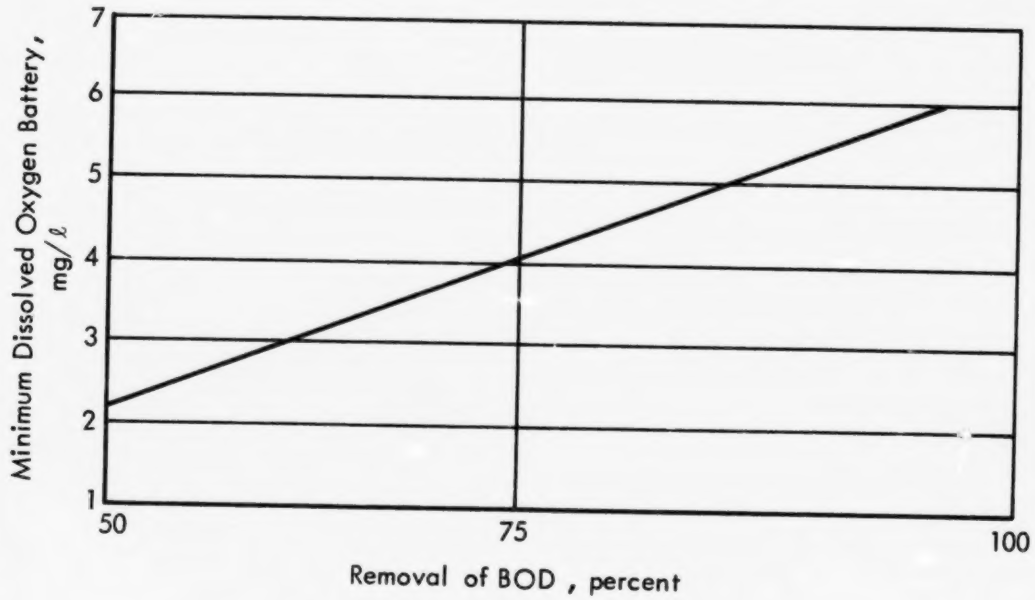


Figure G-10. Idealized Response of Minimum Dissolved Oxygen in the Lower Hudson to Bod Loading

ECONOMIC CONTRIBUTION OF THE ESTUARINE ASSIMILATIVE CAPACITY

Unit Costs of Waste Treatment

Table G-6 summarizes the estimated unit costs of waste treatment (see "Notes to Appendix G"). Secondary treatment refers to the complete treatment process, including primary treatment. Cost of the incremental secondary treatment, though, refers only to the secondary plant facilities required in addition to existing primary plants. Similarly, incremental tertiary treatment implies the addition of tertiary processes to existing secondary facilities. As indicated in "Notes Appendix G", costs per unit of BOD removed are based upon a waste containing a 5-day BOD equal to 250 ppm, 30 percent being removed in primary plants and an additional 55 percent being removed in secondary plants. Removal ob BOD in tertiary plants is based upon a 9 mg/ℓ reduction, from 10 mg/ℓ to 1 mg/ℓ. All costs have been adjusted to 1968 dollars by application of engineering cost ratios. Capital costs were amortized over 20 years at an interest rate of 5 percent.

The Economic Value of Selected Estuaries

Table G-7 summarizes the BOD removals required to achieve incremental 1 mg/ℓ increases in the minimum dissolved-oxygen concentration for the estuaries previously examined. Existing levels of overall treatment in these estuaries have been estimated

TABLE G-6. APPROXIMATE COSTS OF WASTE TREATMENT

Type of Treatment	Approximate	
	Dollars/Million Gallons Treated	Dollars/Pound of BOD Removed
Primary	90	0.150
Secondary	130	0.080
Incremental secondary	40	0.040
Incremental tertiary	150	2.00

TABLE G-7. BOD REMOVALS REQUIRED TO ACHIEVE 1 MG/ℓ INCREASE IN MINIMUM DISSOLVED OXYGEN

Estuary	BOD Removal, lb/day
Delaware	100,000
Potomac	28,000
James	39,000
East	51,000
Hudson	187,000

to range from about 40 to 60 percent removal of BOD. Thus, additional BOD removal in most cases can be accomplished primarily by the addition of secondary treatment facilities to existing primary treatment plants. In Table G-6, the estimated cost of treatment in such facilities is estimated to be about $0.04 per pound of BOD removed. On this basis, Table G-8 summarizes the surface area of each estuary under study and the economic contribution of the estuaries' assimilative capacity for each 1 mg/ℓ decrease allowed in the minimum dissolved oxygen concentration.

It should be pointed out that the values indicated in Table G-8 are based upon the addition of secondary facilities to existing primary treatment plants, with an incremental cost of BOD removal of $0.04/lb. Since all treatment plants in a region are brought up to the level of secondary treatment, additional BOD removal, which would be provided by tertiary treatment facilities, would have the effect of increasing the economic worth per incremental unit of natural assimilative capacity of the estuary by a factor as much as 50.

TABLE G-8. ECONOMIC CONTRIBUTION OF ESTUARINE ASSIMILATIVE CAPACITY PER MG/ℓ OF DISSOLVED OXYGEN

Estuary	Economic Contribution		Surface Area, acres
	dollars/day	dollars/year	
Delaware	4000	1,460,000	70,500
Potomac	1120	408,000	17,000
James	1560	570,000	5,120
East	2040	745,000	18,800
Hudson	7450	2,720,000	5,250
	TOTAL	5,903,000	116,670

ASSIMILATION OF THERMAL LOADINGS

Introduction

Two general categories of beneficial effects can be associated with the release of heat to the aquatic environment: (1) the natural cooling processes involving direct heat exchange with the marine environment can be substituted for costly cooling facilities that disperse the heat into the air or soil, and (2) under certain ecological conditions, beneficial responses can be evoked from the marine ecology. In the following discussion, the economic value of the marine environment's natural cooling capacity in terms of facility substitution is estimated quantitatively. However, since the ecological effects are (1) a function of the specific ecosystem involved and (2) the implications have not been widely studied, this effect is discussed only in general terms.

Analytical Approach for Predicting Environmental Response

Except for some preliminary work conducted in England several years ago with limited success, generalized models for predicting directly the temperature response of a stream or estuary to thermal loadings are not available in the same form as models relating dissolved oxygen levels to BOD loadings. Existing studies of thermal loadings have been limited in the United States to empirical dye-dispersion studies for prediction of temperature distribution.

Dye-dispersion studies employed a fluorescent-dye tracer to simulate the heated effluent. From these, Pritchard and Carter developed a model based on physical processes of movement and dispersion of the effluent.* Both the nonconservative process of boundary cooling and the conservative distribution of the effluent are considered by the model, which is summarized in "Notes to Appendix G".

Excess Temperature Response of Selected Estuaries

Patuxent River Estuary. After circling the eastern outskirts of Washington, D.C., the Patuxent River merges into an estuary that eventually empties into Chesapeake Bay about 50 miles southeast of Washington. The Pritchard and Carter model was originally developed to predict the temperature response of the Patuxent Estuary to several discharges from the PEPCO power plant to be built at Chalk Point (See Figure G-11).

The Chalk Point plant is a conventional thermal generating facility using fossil fuel. According to the Pritchard and Carter study, the plant was to be operated initially with a single 350-MW generator. Ultimately, a total of four 350-MW generators were planned, and it was estimated that the thermal discharge from the condensers would be 4.3×10^6 Btu/hour per megawatt of power produced. For the initial 350-MW generator, the thermal loading to the estuary was estimated to be 3.6×10^{10} Btu/day.

Based on a series of assumptions, the excess temperature distribution upstream and downstream of the power station were estimated by Pritchard and Carter (see Table G-9). In addition to the actual temperature rise anticipated from the discharge of the 350-MW generator, the expected temperature rise for 10^{10} Btu/day has also been calculated for this analysis to provide comparison with data for the Potomac and Thames estuaries. Pritchard and Carter stated that temperature predictions could not be extended to an area within 100 yards of the power plant, since the relatively large volume rate of discharge within this zone would yield a distribution different from that predicted by dye studies employing a very low volume rate of discharge. Figure G-12 describes the excess temperature response of the estuary to thermal discharges for distances varying from 1,000 to 8,000 yards downstream of the Chalk Point power plant.

Since there exists a linear relationship between the temperature rise of a point and the rate of heat addition, Figure G-12 may be used with the Pritchard and Carter data to determine the excess temperature at any point in the estuary for various Btu inputs. Figure G-13 indicates the response of the excess temperature 1,000 yards downstream as a function of the percentage reduction in Btu input at the source. From the slope of the curves it can be determined that each 0.1 degree Fahrenheit decrease in the 1,000 yard downstream excess temperature requires removal of 1.9 percent of the 3.6×10^{10} Btu/day load, or 0.0684×10^{10} Btu/day.

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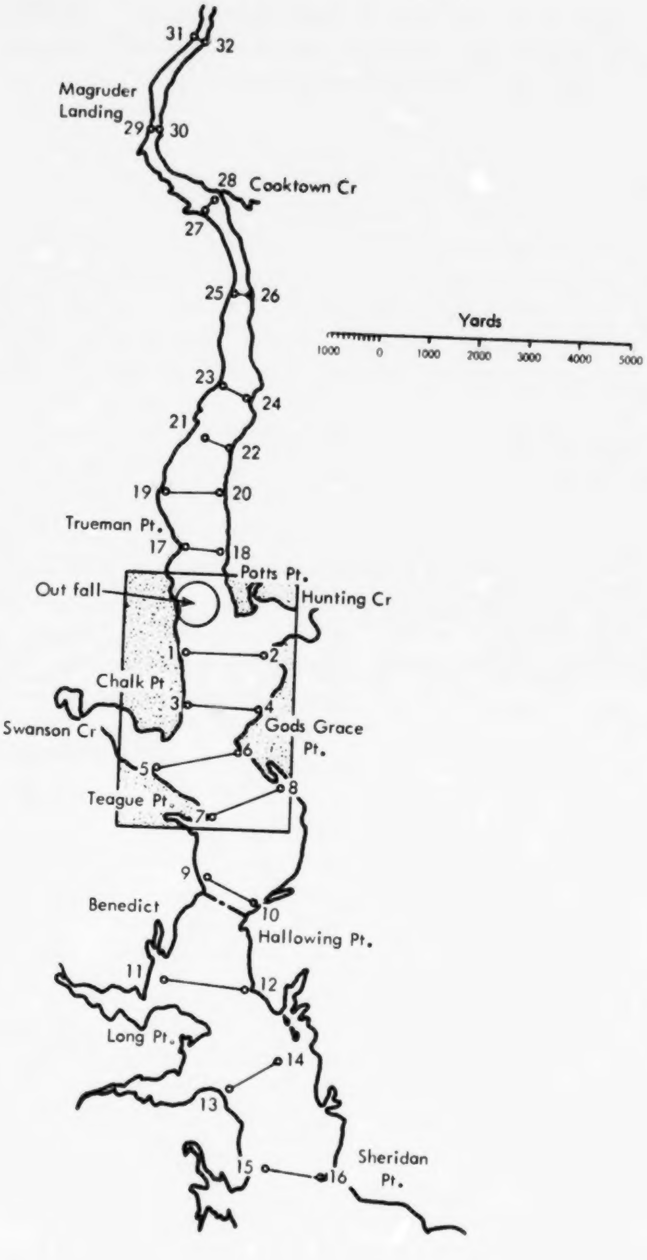
*D.W. Pritchard and H.H. Carter, On the Prediction of Excess Temperature From a Heated Discharge in an Estuary, Technical Report No. 33, Chesapeake Bay Institute, The Johns Hopkins University (1965).


31
32
Magruder Landing
29
30
28
Cooktown Cr
27
25
26
Yards
1000
0
1000
2000
3000
4000
5000
23
24
21
22
19
20
Trueman Pt.
17
18
Potts Pt.
Out fall
Hunting Cr
1
2
Chalk Pt
3
4
Gods Grace Pt.
Swanson Cr
5
6
8
Teague Pt.
7
9
Benedict
10
Hallowing Pt.
11
12
Long Pt.
14
13
Sheridan Pt.
15
16

Source: Prichard D. W., and H. H. Carter, "On the Prediction of Excess Temperature from a Heated Discharge in an Estuary", Technical Report No. 33, Chesapeake Bay Institute, The Johns Hopkins University (1965).

Figure G-11. The Patuxent River Estuary

TABLE G-9. TEMPERATURE DISTRIBUTIONS IN THE PATUXENT ESTUARY UPSTREAM AND DOWNSTREAM OF THE PEPCO POWER PLANT

Temperature Distribution Upstream of Power Station			Temperature Distribution Downstream of Power Station		
Distance, yards	Excess Temperature, degrees F		Distance, yards	Excess Temperature degrees F	
	Per 350-MW Generator(a)	Per 10^{10} Btu/day		Per 350-MW Generator(a)	Per 10^{10} Btu/day
1000	4.20	1.17	1000	5.3	1.47
2000	3.70	1.03	2000	4.7	1.31
3000	3.05	0.85	3000	4.1	1.14
4000	2.95	0.82	4000	2.8	0.78
6000	2.45	0.68	6000	2.0	0.56
8000	2.40	0.66	8000	1.2	0.33

(a) Corresponds to 3.6 x 10^{10} Btu/day.

Potomac River Estuary. To assess the assimilative capacity of the Potomac Estuary for thermal loadings, the data and analyses of Hetling and O'Connell, who generated mass balance relationships for Rhodamine dye in sixteen segments of the Potomac Estuary, have been used as a basis (see Figure G-14).* Applying the data to the Pritchard and Carter model, and assuming critical data where not available, the excess temperature distribution in the estuary was calculated as a function of a hypothetical 10^{10} Btu/day thermal input at the midpoint of Section 5. The magnitude and location of the thermal loading have been selected arbitrarily in the absence of actual loadings so that an estimate of assimilative capacity could be obtained on a basis comparable to similar estimates generated for the Patuxent and Thames estuaries. The excess temperature profile for this hypothetical loading is shown in Figure G-15. The excess temperature 1,000 yards downstream of a heat input at the midpoint of Section 5 as a function of percentage removal of the assumed 10^{10} Btu/day thermal load is shown in Figure G-16.

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*L. J. Hetling and R. L. O'Connel, A Study of Tidal Dispersion in the Potomac River, C-SRBP Technical Paper No. 7, FWPCA, Region III (undated).

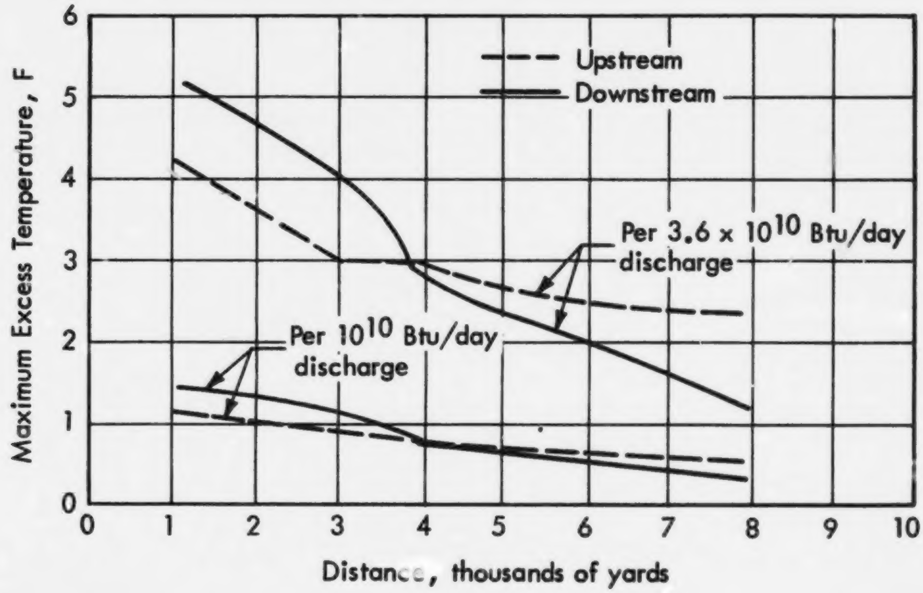


Figure G-12. Excess Temperature Response of the Patuxent River Estuary to Thermal Discharges at Chalk Point Power Plant

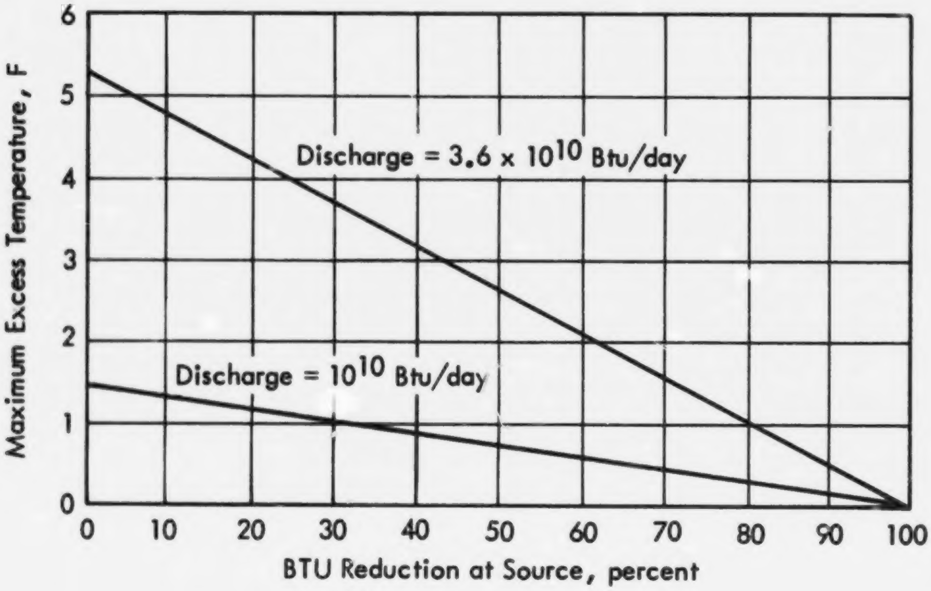
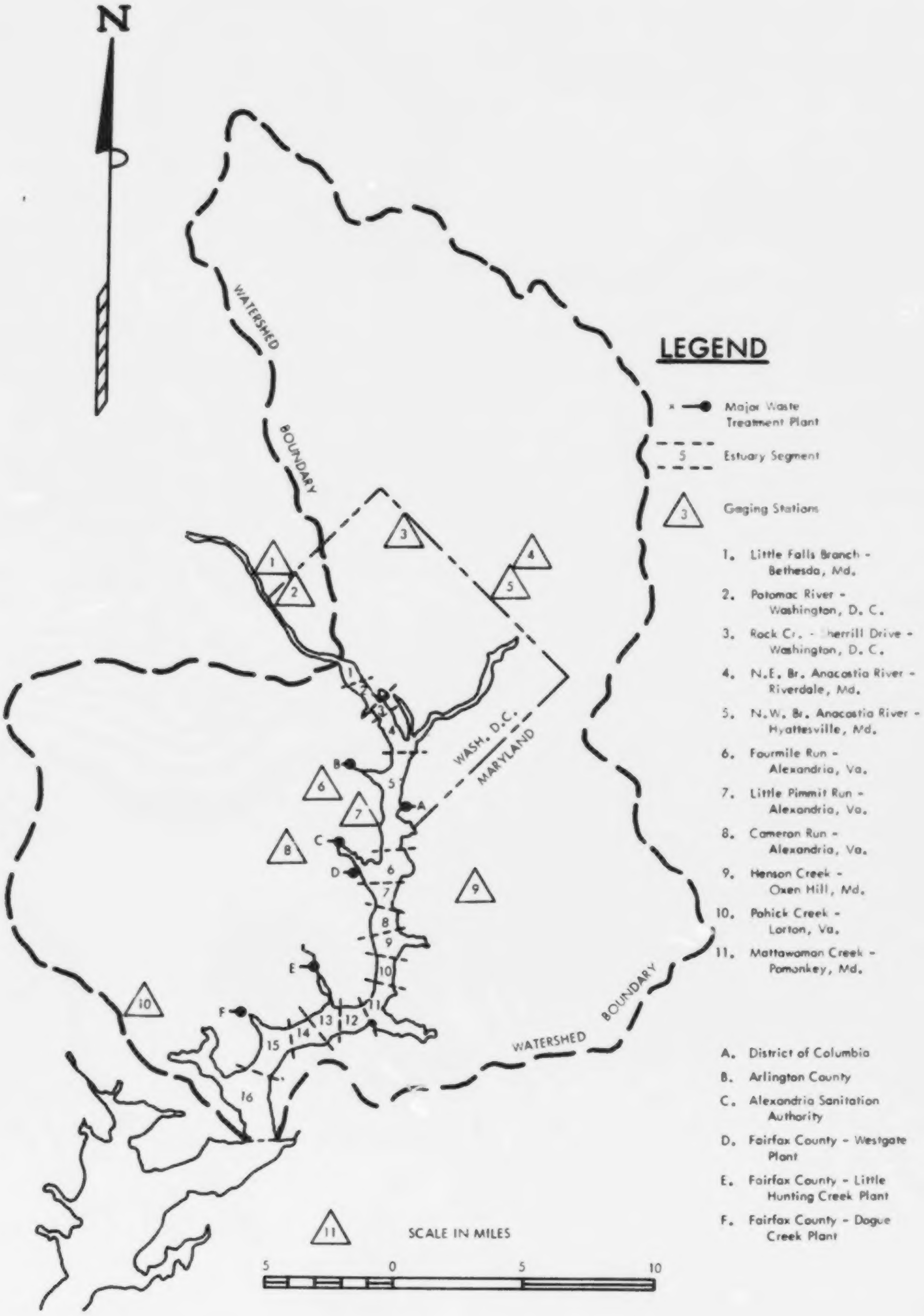


Figure G-13. Excess Temperature Response of Patuxent River Estuary 1000 Yards Downstream of Chalk Point Power Plant Discharge


N
WATERSHED BOUNDARY
WASH, D.C.
MARYLAND
LEGEND
Major Waste Treatment Plant
Estuary Segment
Gaging Stations
1. Little Falls Branch - Bethesda, Md.
2. Potomac River - Washington, D. C.
3. Rock Cr. - Sherrill Drive - Washington, D. C.
4. N.E. Br. Anacostia River - Riverdale, Md.
5. N.W. Br. Anacostia River - Hyattesville, Md.
6. Fourmile Run - Alexandria, Va.
7. Little Pimmit Run - Alexandria, Va.
8. Cameron Run - Alexandria, Va.
9. Henson Creek - Oxen Hill, Md.
10. Pohick Creek - Lorton, Va.
11. Mattawoman Creek - Pomonkey, Md.
A. District of Columbia
B. Arlington County
C. Alexandria Sanitation Authority
D. Fairfax County - Westgate Plant
E. Fairfax County - Little Hunting Creek Plant
F. Fairfax County - Dogue Creek Plant
SCALE IN MILES
5
0
5
10

Source: Hetling, L. J., and R. L. O'Connel, A study of Tidal Dispersion in the Potomac River, C-SPBP Technical Paper No. 7, FWPCA, Region III (undated).

Figure G-14. The Potomac River Estuary

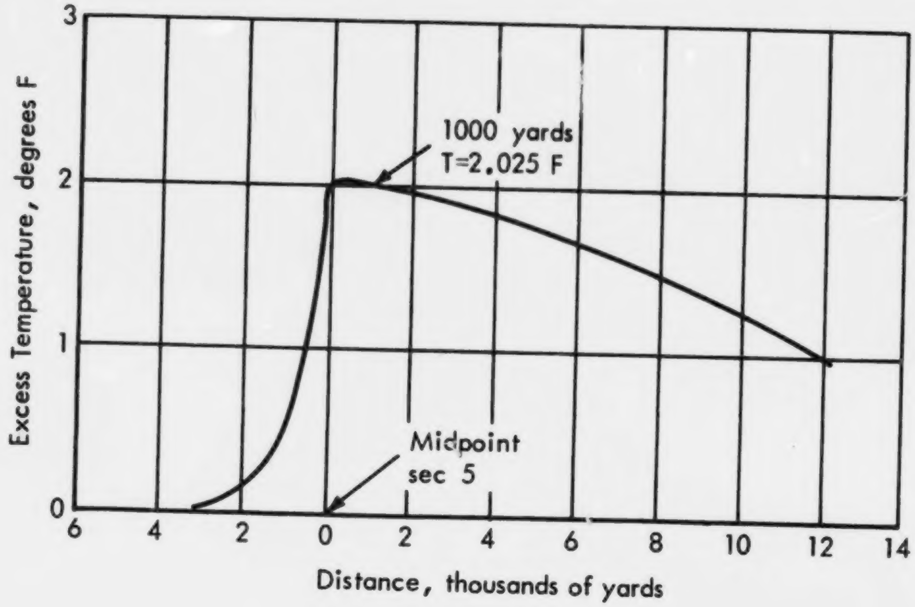


Figure G-15. Excess Temperature Response of the Potomac Estuary to 10^{10} Btu/Day Thermal Discharge at Section 5

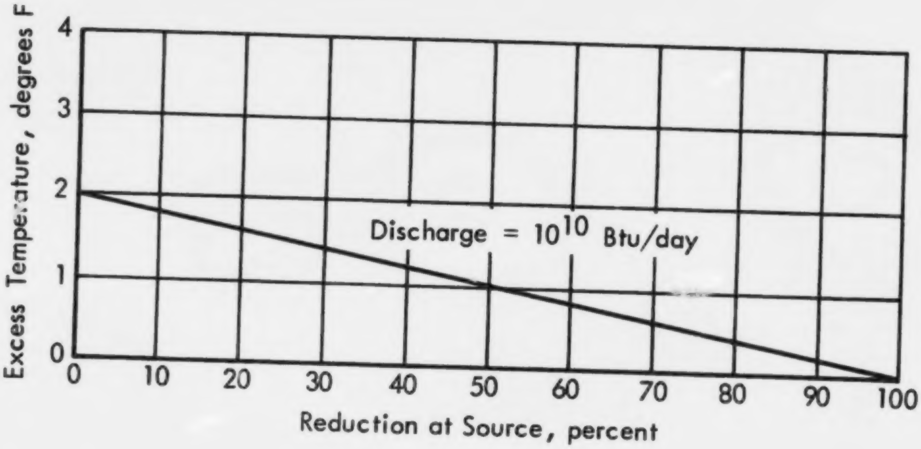


Figure G-16. Excess Temperature Response of Potomac Estuary 1000 yards Downstream to Thermal Discharge in Section 5

The slope of the curve in Figure 16 indicates that each incremental 0.1-degree-Fahrenheit decrease in the excess temperature requires 5 percent reduction in the assumed 10^{10} Btu/day loading. Again, the above analysis applies only to the assumed loading intensity and pattern. Changes in location of the single source, the addition of multiple sources, and changes in the intensity of loading will significantly affect the analysis.

Thames River Estuary. Considerable data is available on the distribution of excess temperature in the Thames Estuary, down river from London (see Figure G-17).* The average rate of heat discharge from various power stations during 1951-54 was estimated to have been 228 x 10^9 Btu/day, about 75 percent of the total heat being contributed by five large plants shown in Figure G-18. Considerable heat was also added from other sources, such as the biochemical activity associated with industrial and domestic sewage effluents. The heat contributions from each of these sources are summarized in Table G-10.

From Table G-10, the total heat load contributed to the estuary is estimated at 306 x 10^9 Btu/day. Heat from fresh-water discharge is attributable primarily to power plants using the upper Thames and river Wandle as a source of cooling water. A mathematical model is presented by Gameson, Hall, and Preddy for predicting the temperature distributions resulting from the fresh water flow, tidal flow, heat addition, cooling, and mixing. Observed and calculated values of excess temperature along the Thames Estuary for the third quarter of 1954 are presented in Figure G-19.

Since this analysis is concerned only with the assimilative capacity of the estuary for thermal discharges, the heating due to biochemical activity and other heat sources are not included in the analysis. On this basis, the total Btu load is 248 x 10^9 Btu/day. Instead of the actual loading of 306 x 10^9 Btu/day, data obtained from Figure G-19 have been employed to determine the excess temperature distribution in the estuary for multiple discharges equal to 10^{10} Btu/day so comparisons are possible with the Patuxent and Potomac estuaries (see Figure G-20). The excess temperature which would be associated with a charge of 248 x 10^9 Btu/day can be calculated by multiplying their values given in Figure G-20 by 24.8. For example, the excess temperature at London Bridge would be about 6 degrees F. The slow rate of change in excess temperature according to empirical data is the result of multiple sources along the estuary.

To compare the assimilative capacity of the Thames estuary with the Potomac and Patuxent data, the excess temperature response as a function of thermal loading at a single point must be established. Data presented by Gameson for hypothetical excess temperature response to a single source discharge of 10^{10} Btu/day 10 miles above London Bridge is shown in Figure G-21.

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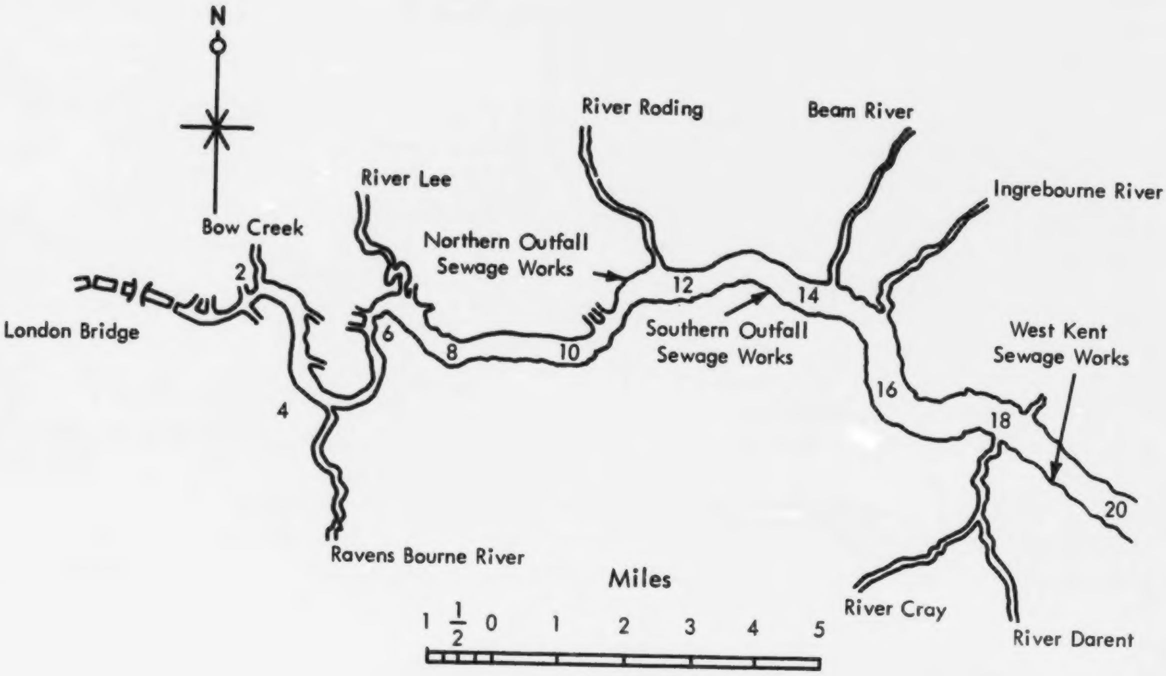
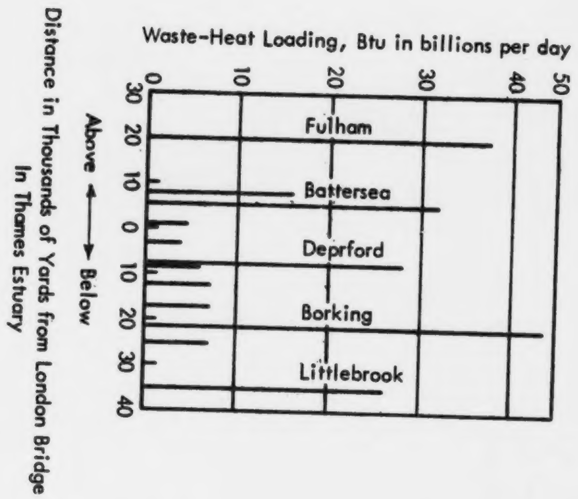
*A. L. H. Gameson, H. Hall, and W. S. Preddy, "The Effect of Heated Discharge on the Temperature of the Thames Estuary, The Engineer (London), pp 819-826 (December 6, 1957); pp 850-852 (December 13, 1957); and pp 893-896 (December 20, 1957). Wilbur N. Torpey, Journal of the Water Pollution Control Federation, "Response to Pollution of New York Harbor and Thames Estuary," Vol. 39, No. 11 (November, 1967), pp 1797-1809.



N
River Roding
Beam River
Ingrebourne River
River Lee
Northern Outfall Sewage Works
Bow Creek
2
London Bridge
6
8
10
12
14
Southern Outfall Sewage Works
West Kent Sewage Works
16
18
4
20
Ravens Bourne River
Miles
1 1/2 0 1 2 3 4 5
River Cray
River Darent

Source: Torpey, W.N., "Response to Pollution of New York Harbor and Thames Estuary", *Journal of the Water Pollution Control Federation*, 29, 11 November 1967, pp. 1797-1809. Reprinted with permission from *Journal of the Water Pollution Control Federation*, 39-11, pp. 1797-1809, November 1967, Washington, D.C. 20016.

Figure G-17. The Thames River Estuary (London Vicinity)



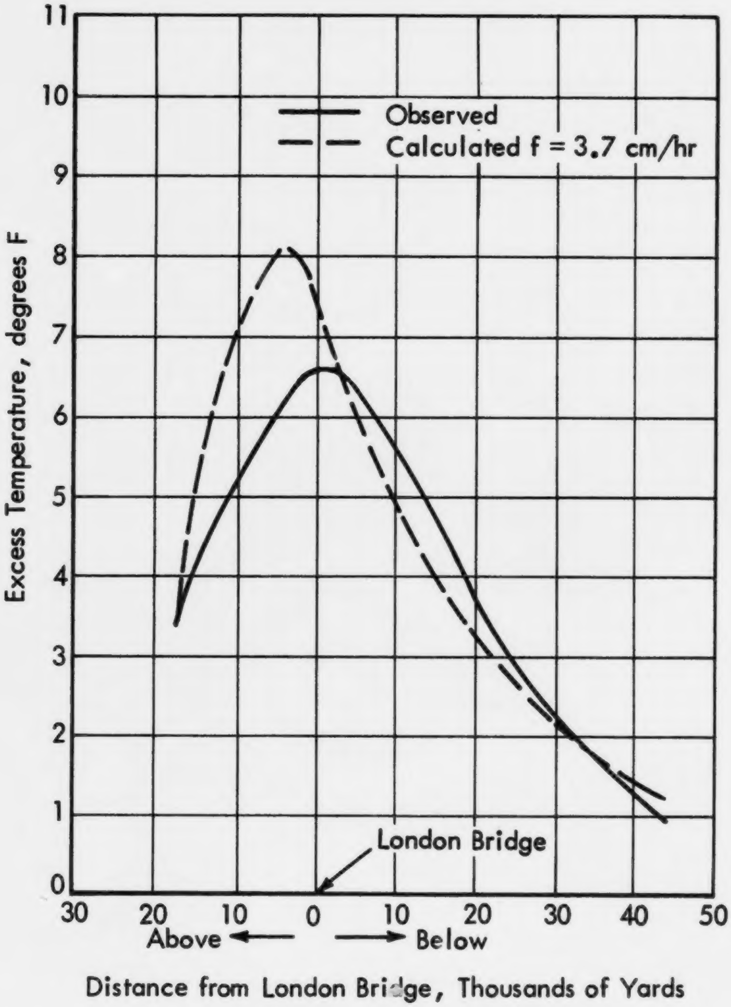
Source: Gameson, A. L. H., H. Hall, and W. S. Preddy, "The Effect of Heated Discharge on the Temperature of the Thames Estuary", The Engineers (London), pp 819-826 (December 6, 1957); pp 850-852 (December 3, 1957); and pp 893-896 (December 20, 1957).

Figure G-18. Waste-Heat Discharge from the Central Electricity Authority During 1951-54

TABLE G-10. AVERAGE HEAT INPUT IN BILLIONS OF BTU PER DAY IN THAMES ESTUARY

Heat Sources	Heat Input	Percent of Total
Power plants	228	74.5
Sewage effluent	27	9.0
Fresh water	20	6.5
Industrial effluents	19	6.0
Biochemical	12	4.0
Total	306	100.0

Source: Gameson, A. L. H., H. Hall, and W. S. Preddy, "The Effect of Heated Discharge on the Temperature of the Thames Estuary", The Engineers (London), pp 819-826 (December 6, 1957); pp 850-852 (December 3, 1957); and pp 893-896 (December 20, 1957).



Source: Gameson, A.L.H., H. Hall, and W.S. Preddy, "The Effect of Heated Discharges on the Temperature of the Thames Estuary", The Engineer (London) pp. 819-826 (December 6, 1957); pp. 850-852 (December 13, 1957) and pp. 893-896 (December 20, 1957).

Figure G-19. Temperature Distribution in the Thames Estuary, Third Quarter 1954

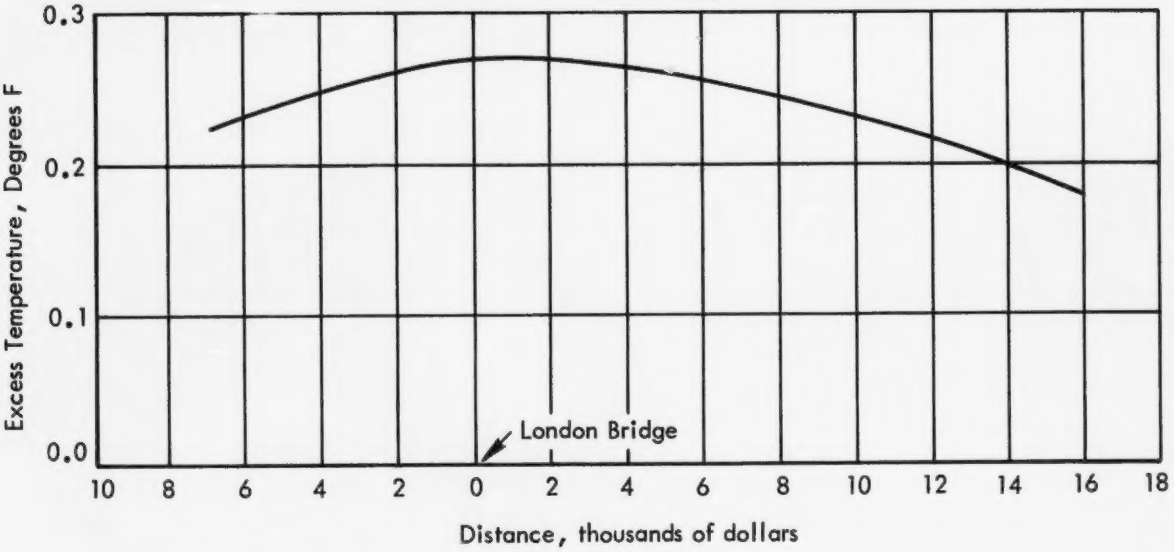


Figure G-20. Excess Temperature Response of Thames Estuary Per 10^{10} Btu/Day Discharge From Multiple Sources

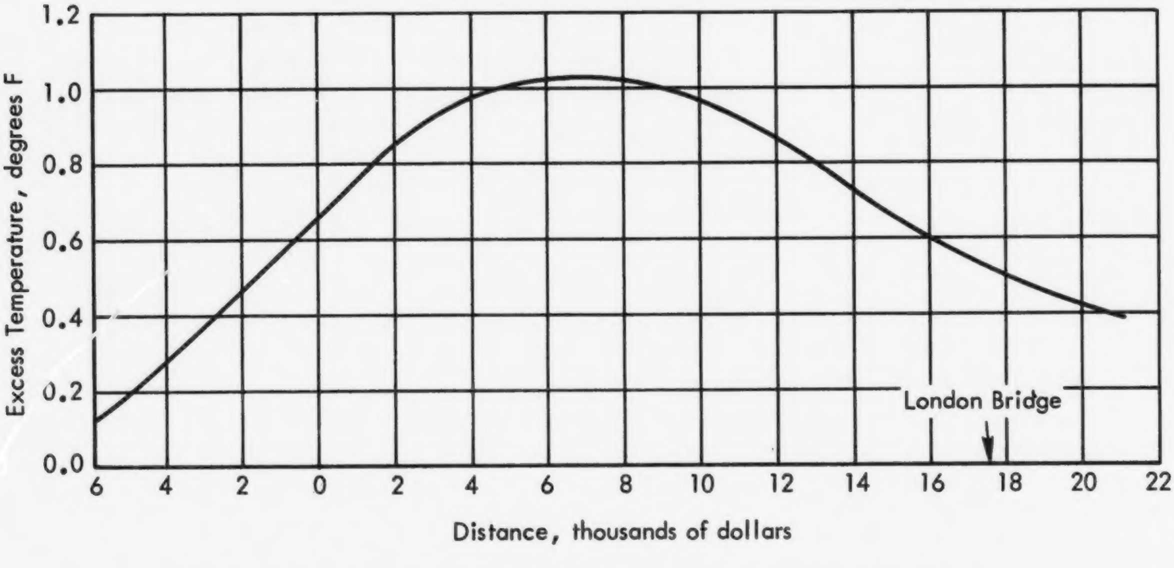


Figure G-21. Estimated Excess Temperature Response of Thames Estuary to Single 10^{10} Btu/Day Discharge 17,600 yards Above London Bridge

It is noted from Figure G-21 that the model employed by Gameson, Hall, and Preddy predicts for this case that the maximum excess temperature occurs an appreciable distance downstream of the single source discharge. No explanation is given by the author for this deviation from the expected response; i. e., maximum excess temperature at the point of discharge. Thus, the reliability of the Thames model is open to question but the data are considered sufficient for an order-of-magnitude estimate being sought.

Figures G-22 and G-23 indicate the response of the maximum excess temperature indicated in Figures G-20 and G-21 to the percentage reduction in respective loadings. It is noteworthy that excess temperature response is much less sensitive to Btu input reduction for the case of multiple sources than it is for single sources. Figure G-23 indicates that a 0.1-degree-Fahrenheit decrease in the maximum excess temperature requires removal of about 9.1 percent of the 10^{10} Btu/day load for a single source 10 miles above London Bridge.

Economic Contribution of Natural Cooling

Unit Costs of Cooling. Detailed calculations for the estimated unit costs of cooling are outlined in "Notes to Appendix G". For the purpose of this report, average values of $9.00 per million gallons treated and $0.045 per million Btu removed have been assumed. These values include both the amortized capital and the operating costs.

Economic Analyses for Selected Estuaries. Based upon excess temperature responses for the estuaries previously described, the reduction in Btu inputs required to achieve each 0.1-degree-Fahrenheit decrease in the maximum downstream excess temperature from thermal loadings is summarized in Table G-11.

Assuming that the cost of cooling is $0.045 per million Btu removed, the economic contribution of the estuarine cooling capacity per 0.1 degree Fahrenheit is summarized in Table G-12.

CONCLUSION

The focus of this analysis has been exclusively on the cost of restoring the environmental quality of estuaries from two waste loadings — organic and thermal. Omitted are the costs of cleansing the waters of industrial wastes, particularly petroleum, now being discharged into the nation's waterways. Furthermore, before the cost estimates of restoring environmental quality can be applied to management decisions, this restoration cost must be compared to the total cost - social and economic - of not restoring full quality. Inevitably, trade-offs would be found.* But with a balanced evaluation of the

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*Allen V. Kneese, The Economics of Regional Water Quality Management (Baltimore: Johns Hopkins, 1964).

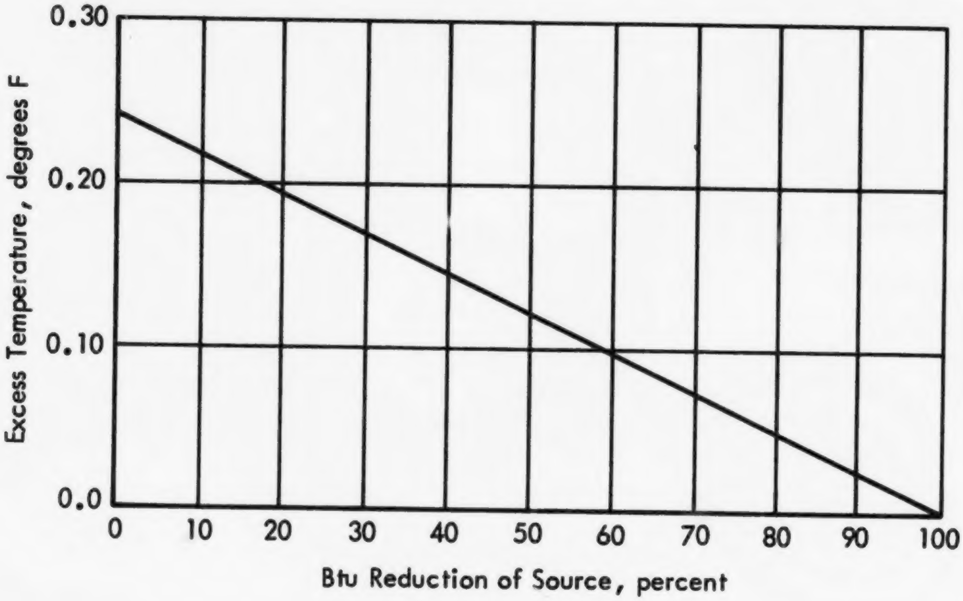

Figure G-22. Maximum Excess Temperature Response of Thames Estuary to Equal Reduction in Total 10^{10} Btu/Day Load at Multiple Sources

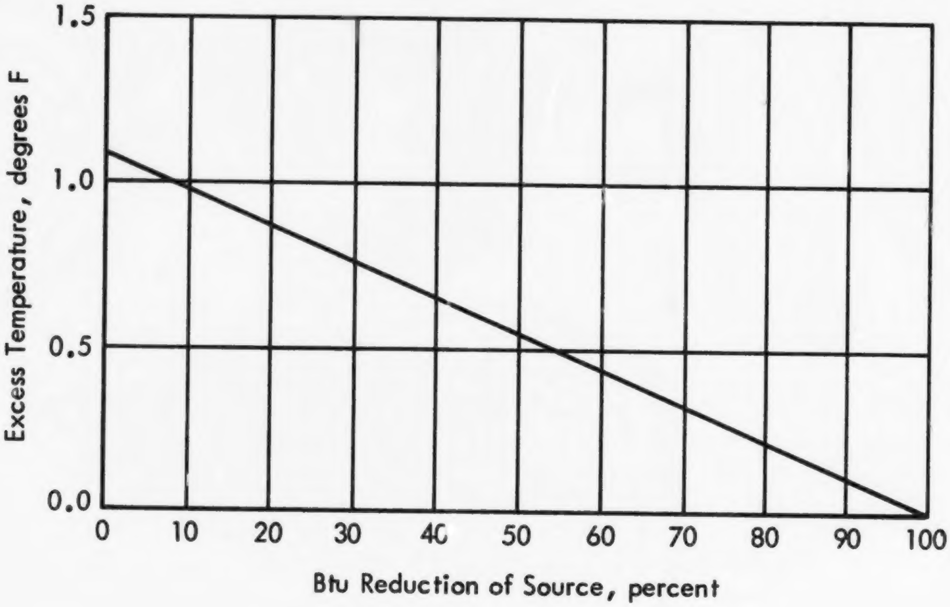

Figure G-23. Maximum Excess Response of Thames Estuary to Reduction in 10^{10} Btu/Day Discharge 10 miles Upstream of London Bridge

TABLE G-11. REDUCTIONS IN THERMAL LOADS REQUIRED TO ACHIEVE 0.1-DEGREE-FAHRENHEIT DECREASE IN MAXIMUM [(a)] DOWNSTREAM EXCESS TEMPERATURE

Estuary	Reduction in Thermal Load, 10^6 Btu/day
Patuxent	700
Potomac	500
Thames	410

(a) Taken to be 1000 yards downstream for Patuxent and Potomac estuaries. Taken to occur 7000 yards downstream in Thames Estuary (see text).

TABLE G-12. ECONOMIC CONTRIBUTION OF ESTUARINE COOLING CAPACITY PER 0.1-DEGREE-FAHRENHEIT INCREASE ALLOWED IN THE MAXIMUM DOWNSTREAM EXCESS TEMPERATURE

Estuary	Economic Distribution		Surface Area, acres
	Dollars/Day	Dollars/Year	
Patuxent	31.50	11,500	7,000
Potomac	22.50	8,200	17,000
Thames	41.00	15,000	7,870
Total		34,700	31,870

two total costs, our society could both more rationally utilize our natural resources and, at the same time, appreciate more fully a rarely recognized national asset, the assimilative capability of our estuaries for discharged wastes.

NOTES TO APPENDIX G

Summary of Analytic Models Used*

DO/BOD Model. The concentration of dissolved oxygen at any point is given as

$$c = c_O e^{j_2 x} + c_s \left[1 - e^{j_2 x}\right] - F L_O \left[e^{j_1 x} - e^{j_2 x}\right]$$

The location of the critical deficit is given as

$$x_c = \frac{1}{j_1 - j_2} \log_e \frac{j_2}{j_1} \left[1 - \frac{D_O}{L_O F}\right]$$

The magnitude of the critical oxygen deficit is given as

$$D_c = \frac{K_d L_O e^{j_1 x}}{K_2} \left[1 + \frac{j_1^2 \epsilon}{K_2 - K_d}\right] - \frac{\epsilon j_2^2 e^{j_2 x}}{K_2} \left[F L_O - D_O\right]$$

where,

$$j_1 = \frac{U}{2\epsilon} \left[1 - \sqrt{1 + \frac{4K_d \epsilon}{U^2}}\right]$$

$$j_2 = \frac{U}{2\epsilon} \left[1 - \sqrt{1 + \frac{4 K_2 \epsilon}{U^2}}\right]$$

$$F = \frac{K_d}{K_2 + U j_1 - \epsilon j_1^2}$$

and

c = concentration of dissolved oxygen

c_o = initial concentration of dissolved oxygen

c_s = saturation value of dissolved oxygen

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*O'Connor, Donald J., "Oxygen Balance of an Estuary", Journal of the Sanitary Engineering Division, American Society of Civil Engineers, 86-SA3 (May, 1960) pp 35-55.

D = dissolved oxygen deficit
D_o = initial dissolved oxygen deficit
D_c = critical dissolved oxygen deficit
K_2 = coefficient of reaeration
K_d = coefficient of deoxygenation
L = ultimate BOD
L_o = ultimate BOD at initial point
L_5 = 5-day BOD
U = velocity due to land runoff
x = longitudinal distance
ϵ = coefficient of eddy diffusion.

Thermal Assimilation Model. The model developed by Pritchard* is summarized by the following expression

$$\Gamma_{h,\infty} = \frac{Q_h}{Q_d} \cdot \Gamma_{d,\infty} \left[\frac{D_d}{D_h + \gamma/\eta} \right]$$

where

η = rate constant (day^{-1}) - (determined from field data)
γ = rate coefficient (depends on wind velocity, temperature of the heated effluent, and natural or unheated temperature of the receiving waters (ft/day)
D_h = vertical extent of heat distribution (feet)
D_d = vertical extent of dye distribution (feet)
Q_h = rate of heat discharge (Btu/day)
Q_d = rate of dye discharge (lb/day)

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*Pritchard, D. W., and H. H. Carter, On the Prediction of Excess Temperature From a Heated Discharge in an Estuary, Technical Report No. 33, Chesapeake Bay Institute, The Johns Hopkins University (1965).

$\Gamma_{d',\infty}$ = steady state concentration of dye at a given point in the estuary resulting from a continuous discharge for an infinite time (ppb or 10^{-9} lb/lb)

$\Gamma_{h,\infty}$ = steady-state concentration of heat at a given point in the estuary resulting from a continuous discharge for an infinite time, taking into account heat loss by cooling (Btu/lb.)

Since 1 Btu is the amount of heat required to raise the temperature of one pound of water one degree F, and since $\Gamma h, \infty$ is given in terms of Btu/lb, the amount of excess temperature, in degrees F, is numerically equal to $\Gamma_{h,\infty}$.

Waste Treatment Costs

Primary and Secondary Treatment. Recent publications containing data on primary and secondary waste-treatment plants were reviewed. Three information sources* were selected and relevant cost data extracted and analyzed. Data are summarized in Table G-13 for (1) primary treatment, (2) complete secondary treatment (including a primary treatment), and (3) incremental secondary treatment (i.e., the addition of secondary facilities to existing primary facilities). All published data reviewed are reported in terms of dollars per unit of flow. Costs in Table G-13 related to BOD removal are based upon a waste stream containing 250 ppm BOD, 30 percent of which is removed in primary plants and an additional 55 percent of which is removed in secondary processes. This is equivalent to the following removals:

(1) Primary (30 percent) - 62.0 pounds BOD per million gallons
(2) Secondary (85 percent) - 177.0 pounds BOD per million gallons
(3) Incremental Secondary (55 percent) - 1150 pounds BOD per million gallons.

All costs have been adjusted to 1968 dollars by the use of various engineering cost indices available. Capital costs have been amortized over a period of 20 years at an interest rate of 5 percent.

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*"Modern Sewage Treatment Plants, How Much Do They Cost ?", U.S. Public Health Service Publication No. 1229, U.S. Government Printing Office, Washington, D.C., 1964.

Gibbs, Charles V., and Bothel, Ray H., "Potential of Large Metropolitan Sewers for Disposal of Industrial Waste", Journal of the Water Pollution Control Federation, 37:10, 1417-1421 (October, 1965).

Rowan, P.P., Jenkins, K.L., and Howells, D.H., "Estimating Sewage Treatment Plant Operation and Maintenance Costs", Journal of the Water Pollution Control Federation, 33:2, 111-121 (February, 1961).

TABLE G-13. PRIMARY AND SECONDARY SEWAGE TREATMENT COSTS

Capacity, mgd	Primary Treatment				Complete Secondary Treatment				Incremental Secondary			
	Amortized Capital, $/mg	Operating, $/mg	Total		Amortized Capital, $/mg	Operating, $/mg	Total		Amortized Capital, $/mg	Operating, $/mg	Total	
			$/Mg	$/Lb BOD Removed			$/Mg	$/Lb BOD Removed			$/Mg	$/Lb BOD Removed
0.1	175.00(a)	80.00(c)	255.00	0.407	208.00(a)	133.00(c)	391.00	0.22	33.00(a)	103.00(c)	136.00	0.118
1.0	79.40(a)	64.50(b)	--	--	99.30(a)	81.80(b)	--		19.90(a)	17.30(b)	--	--
1.0	72.50(b)	36.80(c)	--	--	119.00(b)	73.50(c)	--		46.50(b)	36.70(c)	--	--
1.0	75.95(d)	50.65(d)	126.60	0.202	109.15(d)	77.65(d)	186.80	0.106	33.20(d)	27.00(d)	60.20	0.052
10	31.20(a)	23.00(c)	54.20	0.087	41.40(a)	41.50(c)	82.90	0.047	10.20(a)	18.50(c)	28.70	0.025
25	34.20(b)	26.60(b)	60.80	0.097	48.00(b)	30.00(b)	78.00	0.044	13.80(b)	3.40(b)	17.20	0.015
100	23.70(b)	17.35(b)	--	--	45.80(b)	20.80(b)	--	--	22.10(b)	3.45(b)	--	--
100	--	18.50(c)	--	--	--	28.00(c)	--	--	--	9.50(c)	--	--
100	23.70(b)	17.93(d)	41.63	0.067	45.80(b)	24.40(d)	70.20	0.039	22.10(b)	6.47(d)	28.57	0.024

(a) Based on data contained in "Modern Sewage Treatment Plants, How Much Do They Cost ?' U.S. Public Health Service Publication No. 1229, U. S. Government Printing Office, Washington, D. C. 1964.

(b) Based on data contained in Gibbs, Charles, V., and Bothel, Ray H., "Potential of Large Metropolitan Sewers for Disposal of Industrial Waste", Journal of the Water Pollution Control Federation, 37:10, 1417-1421 (October, 1965).

(c) Based on data contained in Rowan, P. P., Jenkins, K. L., and Howells, D. H., "Estimating Sewage Treatment Plant Operation and Maintenance Costs", Journal of the Water Pollution Control Federation, 33:2, 111-121 (February, 1961).

(d) Represents average when more than one value is available.

Incremental Tertiary Treatment. Estimated incremental capital and operating costs of tertiary sewage treatment are based upon data published by Culp and Roderick* for a tertiary process designed for the South Lake Tahoe Utility District. The costs presented are for a chemical coagulation process employing polyelectrolytes, plus carbon adsorption. Costs presented by Culp and Roderick are presented in terms of dollars/mgd. These have been converted to dollars/million gallons. In addition, costs have been calculated in terms of dollars per pound of BOD removed, assuming a 9 mg/ℓ Capital costs have been amortized over 20 years at an interest rate of 5 percent. All costs are summarized in Table G-14. It is seen from Tables G-13 and G-14 that tertiary treatment roughly doubles the cost of sewage treatment in terms of dollars per gallon treated.

Summary. It is noted from the data presented in Tables G-13 and G-14 that treatment costs vary significantly with plant size. These costs are plotted in Figures G-24 and G-25. The majority of plants constructed in the United States are in the size range 1 to 10 mgd and it seems reasonable to use arbitrarily the cost data for 4 mgd plants for establishing the economic data required in this study. The following costs will therefore be used:

	Cost, $/mg	Cost, $/lb BOD removed
Primary treatment	90	0.150
Secondary treatment	130	0.080
Incremental secondary treatment	40	0.040
Incremental tertiary treatment	150	2.000

Cooling Costs

Capital costs of cooling towers including installation are given in Perry's Chemical Engineers' Handbook.** These have been adjusted to 1968 dollars and are summarized in Table G-15.

Using data published by Berg, et al.***, power costs have been estimated to range from $2.00 to $5.00 per million gallons, and from $0.015 to $0.022 per million Btu removed.

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*Culp, Russell, L., and Roderick, R.E., "The Lake Tahoe Water Reclamation Plant", Journal of the Water Pollution Control Federation, 38:2, 147-155 (February, 1966).

**Perry, John H., Chemical Engineers' Handbook, 4th Edition, McGraw Hill, New York (1963).

***Berg, Brian, R.W. Lane, and T.E. Larson, Water Use and Related Costs With Cooling Towers, Illinois State Water Survey, Circular 86, Urbana, Illinois (1963).

TABLE G-14. INCREMENTAL COSTS OF TERTIARY SEWAGE TREATMENT

Plant Capacity (mgd)	Amortized Capital Cost		Operating Cost		Total Cost	
	$/Million Gallons	$/Lb BOD Removed	$/Million Gallons	$/Lb BOD Removed	$/Million Gallons	$/Lb BOD Removed
2.5	61.60	0.820	103.00	1.37	164.60	2.190
10.0	45.90	0.623	77.50	1.03	123.40	1.653
50.0	41.50	0.553	65.00	0.865	106.50	1.418
100.00	37.30	0.496	61.80	0.824	99.10	1.320
200.00	34.70	0.461	59.00	0.784	93.70	1.245

Source: Culp, Russell, L., and Roderick, R.E., "The Lake Tahoe Water Reclamation Plant", Journal of the Water Pollution Control Federation, 38:2, 147-155 (February, 1966).

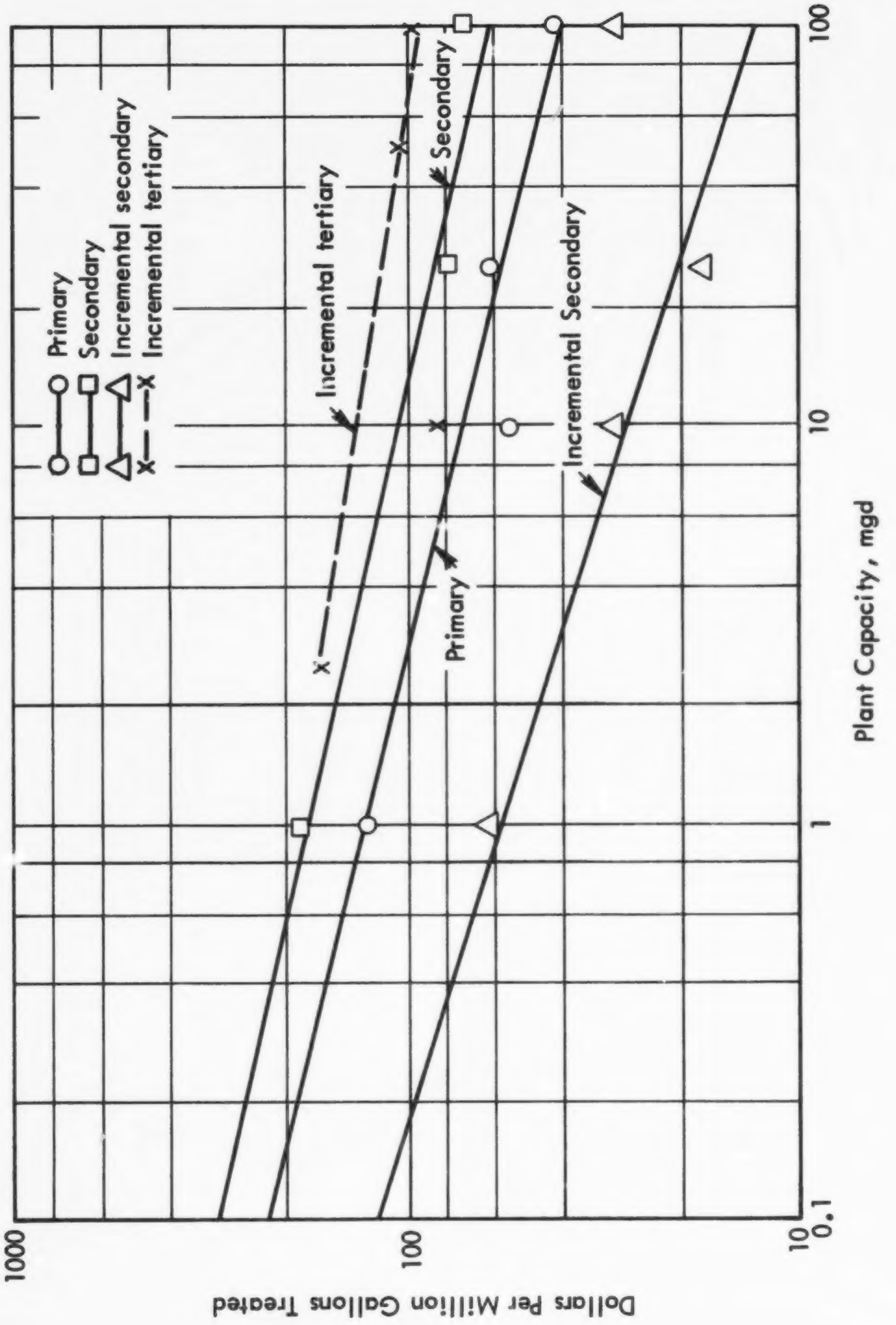

Figure G-24. Costs of Waste Treatment

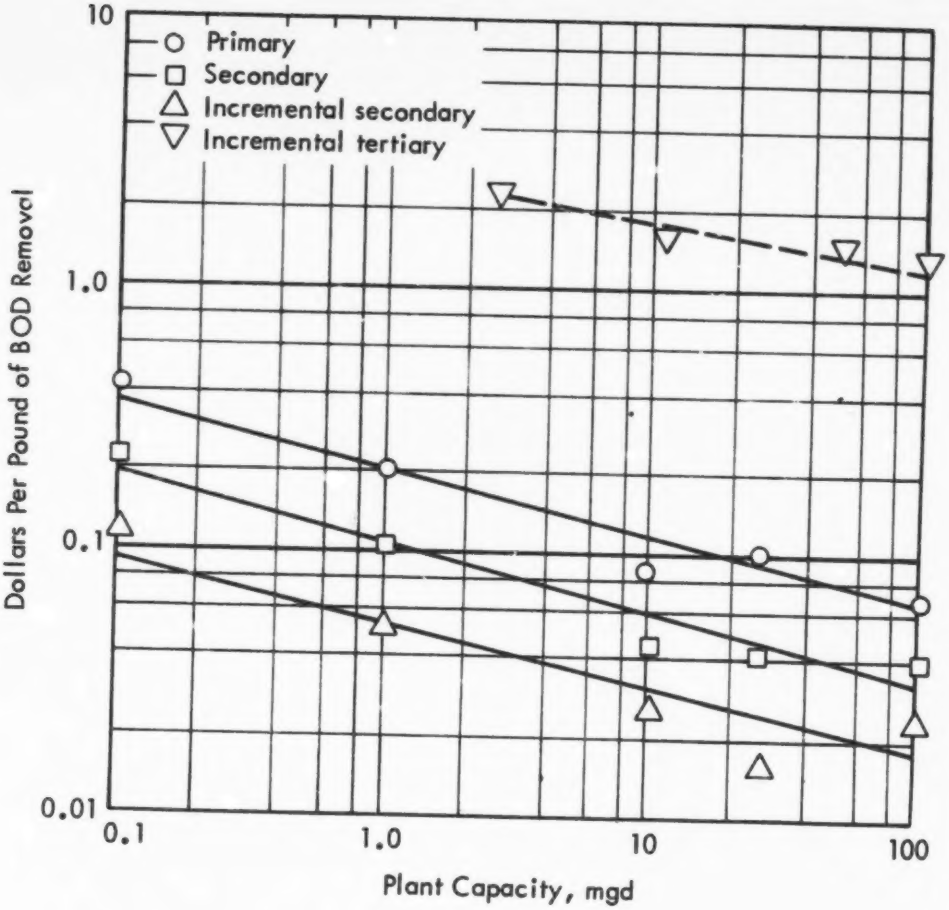

Figure G-25. Costs of Waste Treatment

TABLE G-15. INSTALLED COSTS OF COOLING TOWERS

Tower Capacity		Cost, ($/million gallons)		Cost, $\$/10^6$ Btu	
gpm	mgd	$\Delta = 30$ F$^{(a)}$	$\Delta T = 15$ F$^{(b)}$	$\Delta T = 30$ F$^{(a)}$	$\Delta T = 15$ F$^{(b)}$
2000	2.88	8.34	6.45	0.0337	0.0515
4000	5.76	5.95	3.40	0.0238	0.0272
6000	8.64	5.20	2.90	0.0208	0.0232
10,000	14.40	4.60	2.55	0.0177	0.0204
18,000	25.90	4.20	2.37	0.0167	0.0197

(a) Represents 85 F wet bulb and 5 F approach.
(b) Represents 75 F wet bulb and 10 F approach.

For purposes of cost estimates to be generated in this study, capital costs will be assumed at $6.00 per million gallons and $0.025 per million Btu removed. Operating costs, which will be almost totally power costs, will be assumed to be $3.00 per million gallons and $0.02 per million Btu removed. Total costs are then assumed to be $9.00 per million gallons and $0.045 per million Btu. Because of the wide variability among cooling towers and other cooling facilities, these costs must be considered as approximations which for any given installation may be in error by a factor of 3 or 4. These figures are nevertheless considered satisfactory for the purpose of the estimates generated in this report.

Needs for Additional Research

Mathematical Model for Assessing the Effect of Thermal Pollution on Estuarine Water Quality. Increasing concern has been voiced in recent years about the effects of thermal loadings from power plants and other industrial sources on the estuarine environment. However, productive techniques and models do not exist which allow one to assess in advance, on the basis of receiving water characteristics, the expected response of the environment (i.e., the excess temperature distribution) to alternative patterns of thermal loadings.

Existing methodology for assessing environmental responses to nonconservative pollutant loads is limited to a variety of mathematical models for predicting the effect of BOD loadings on dissolved oxygen depletion. Methods for the analysis of thermal pollution effects are extremely limited. One recently developed technique employs dye tracer studies to generate data upon which predictions of excess temperature distribution may be based.* However, these studies are costly to conduct. Researchers at Johns Hopkins have developed a procedure for determining the temperature distribution that would result from increasing the size of a power plant based upon the existing distribution of excess temperature.** Consequently, a need exists for developing methods of modeling the mass and energy balances on a receiving body so that excess temperature distributions can be predicted solely on the basis of the physical and hydrological characteristics of the receiving body.

After development of the thermal response model a next logical step would be to integrate the thermal model with existing BOD responses models to include synergistic and antagonistic effects. For example, increased temperatures from thermal discharges decrease the saturation level of dissolved oxygen, and hence, reaeration rates, but increase the rate of BOD decay. These effects are not included in existing pollution response models.

Following completion of the above efforts a logical extension would be to incorporate the effects of the stochastic nature of the system inputs (streamflows, waste loadings, wind, sunlight, etc.). Efforts have been initiated to incorporate stochastic phenomena into BOD response models*** and an extension to thermal models and combined thermal - BOD models would provide considerable improvement to existing techniques.

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*Pritchard, D.W., and Carter, H.H., On the Prediction of Excess Temperature From A Heated Discharge in an Estuary, Technical Report No. 33, Chesapeake Bay Institute, Johns Hopkins University (1965).

**Edinger, John Eric, and John C. Geyer, "Analyzing Steam Electric Power Plant Discharges", Journal of the Sanitary Engineering Division, ASCE, 94 (SA4), 611-623 (August, 1968).

***Thayer, Richard P., and Richard G. Krutchkoff, A Stochastic Model for Pollution and Dissolved Oxygen in Streams, Water Resources Research Center, Virginia Polytechnical Institute, Blacksburg, Virginia (August, 1966).
Kothandarman, Veerasamy, Probabilistic Analysis of Wastewater Treatment and Disposal Systems, Research Report No. 14, Water Resources Center, University of Illinois, Urbana, Illinois (June, 1968).

APPENDIX H

DEVELOPMENT OF CHESAPEAKE BAY RESOURCES

Gerald Nehman and Ira Whitman

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APPENDIX H

DEVELOPMENT OF CHESAPEAKE BAY RESOURCES

by

Gerald Nehman
Ira Whitman

GENERAL DESCRIPTION

The Chesapeake Bay is the largest inlet in the Atlantic coastal plain. It is approximately 180 miles long, varies in width from 3 to 30 miles, and covers a total area of 4300 square miles. The Bay is a fairly shallow body of water and requires extensive dredging to maintain ship channels into Baltimore Harbor.

The drainage basin of the Bay includes an area of 74,000 square miles: 42 percent of this area is drained by the Susquehanna, 22 percent by the Potomac, and an additional 24 percent by the Rappahannock, York, and James rivers on the Western Shore.* Emptying into the Bay from the Eastern Shore are the Wicomico, Nanticoke, Choptank, and Chester Rivers.

THE HISTORICAL DEVELOPMENT OF THE CHESAPEAKE BAY

Indian tribes living along the Bay prior to the arrival of European settlers supplemented their food supply with fin fish and shellfish, and used the shell to make hand tools. The many navigable rivers and the Bay facilitated travel throughout the region. The early settlers, arriving around 1634, also oriented their livelihood around the Bay and its tributaries.

The most important early commercial development on the Bay was the tobacco industry. Plantation agriculture developed along the waterways with each locality having its own docks for delivery of supplies and overseas shipment of tobacco. At the beginning of the eighteenth century, the shipbuilding industry grew in response to a need for vessels to transport the tobacco crop.

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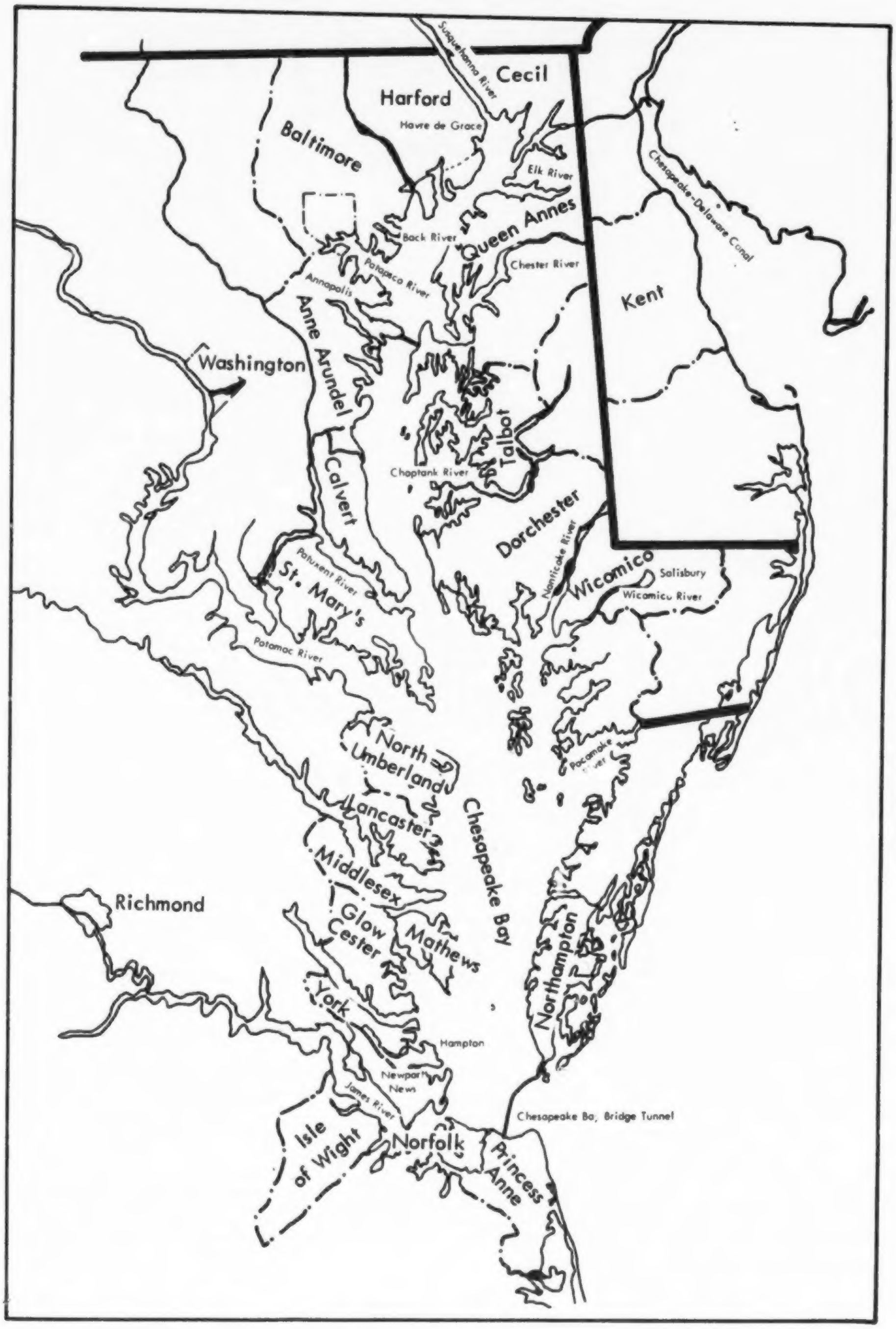
*L. Eugene Cronin, The Conditions of the Chesapeake Bay, Transactions of the Thirty-Second North American Wildlife and Natural Resources Conference, Published by Wildlife Management Institute, 1967, p 137+.


Cecil
Harford
Susquehanna River
Havre de Grace
Baltimore
Elk River
Chesapeake-Delaware Canal
Back River
Queen Annes
Patapsco River
Annapolis
Chester River
Kent
Washington
Anne Arundel
Talbot
Choptank River
Calvert
Dorchester
Nanticoke River
Patuxent River
St. Mary's
Wicomico
Salisbury
Wicomico River
Potomac River
North Umberland
Pocomoke River
Lancaster
Chesapeake Bay
Middlesex
Richmond
Glow Cester
Mathews
Northampton
York
Hampton
Newport News
James River
Chesapeake Bay Bridge Tunnel
Isle of Wight
Norfolk
Princess Anne

Chesapeake Bay Region

Toward the end of the eighteenth century there was a severe decline in tobacco prices. This price decline, coupled with a depleted land resource, reduced tobacco production in the area at the same time that ship building was becoming an important industry. Two conditions were favorable for the development of this industry: first, extensive forests provided a good supply of timber, tar, pitch, and turpentine; second, the navigable rivers and creeks were excellent protected areas for shipbuilding and excellent places to store wooden ships during periods when infestations from wood borers and barnacles were heaviest. *

After the Revolutionary War, the first dredges began to operate in the Chesapeake, deepening channels and docking areas. Increased commerce and shipbuilding encouraged the development of more centralized marketing areas. Whereas in the early period each plantation maintained its own docking facilities, they now became more centralized around Baltimore and Norfolk. ** Centralization was encouraged by two factors: the trend towards construction of large steel vessels requiring specialized construction facilities, and the development of railroads connecting the coastal cities with the Ohio Valley.

The fishing industry did not develop in the Chesapeake Bay until the 1840's when New Englanders came to the area to exploit the oyster fishery. *** Prior to this time, local colonists used the oyster's shell as flux for iron smelting, for making roads, and in mortar, but they had not appreciated its food value. The development of canneries and the railroad system both contributed to the expansion of this market. ****

DEMOGRAPHIC CHARACTER OF THE CHESAPEAKE BAY REGION

Today, the population surrounding the Chesapeake Bay is concentrated in Baltimore and Norfolk. The residents of these two urban areas are the major recipients of wealth derived from the Bay's resources. From 1940 to 1960, population growth in Maryland and Virginia has been more rapid than the national average and in both states the major growth areas have been in the coastal counties.

Thirty percent of the population of Maryland resides in counties contiguous with the Chesapeake Bay. Over 50 percent of the coastal population is found in Baltimore County which has been experiencing very rapid population growth during the last

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*Middleton, A. P., Tobacco Coast, A Maritime History of Chesapeake Bay in the Colonial Era, The Mariners Museum, Newport News, Virginia, 1953, pp 36.

**Brewington, M. V., Chesapeake Bay, Pictoral Maritime History, Cornell Martime Press, Cambridge, Maryland, 1953, pp 36.

***Middleton, A. P., Op. Cit., pp 57-58.

****Radoff, B., The Old Line State, History of Maryland, Historical Record Assoc., Annapolis, Md., 1956, p 294.

15 years. The population of the Western Shore increased 53 percent between the 1950 and 1960 census which was 20 percent faster than the growth rate of the state as a whole. The Eastern Shore grew about 8 percent during the same period (Table H-1). This rate of growth has been increasing since 1960 because of access via the two Bay Bridges. The Bay Bridge-Tunnel from Norfolk to Cape Charles and the new Bay bridge under discussion at the present time should continue to accelerate growth of this area.

Twenty-three percent of Virginia's population resides in the twelve counties contiguous to the Chesapeake Bay shoreline. Population growth in these counties has been increasing about 14 percent faster than has the state as a whole, during the 1950-1960 period. The main source of population growth in this area (33 percent from 1950 to 1960) is immigration generated by growth of the shipbuilding industry.* This trend will probably continue because of the large growth in Princess Anne County and the cities of Hampton, Newport News, Norfolk, and Portsmouth. The two counties on the tip of the Delmarva Peninsula declined in population from 1950 to 1960 and probably will not experience substantial growth for some time (Table H-1).

Thus, for both Maryland and Virginia, the Chesapeake Bay has continued to be a focus of economic activity, and hence, population concentrations. This increase in population has intensified the management problems of the Bay as the demands for its resources has increased. These problems have been studied to some extent from the standpoints of recreation, the fishery, water consumption, waste disposal, and transportation. This appendix summarizes and analyzes these studies in terms of the new information that it provides researchers and managers concerned with Chesapeake Bay management.

WASTE ASSIMILATION

There have been few pollution problems in the Bay proper. This is partly a result of the large volume of water circulating in the Bay, but more important, the tributaries assimilate most of the pollutants from urban and industrial centers. Since waste assimilation is confined to the river basins, they have been studied as entities.

Eastern Shore

The major drainage basins on the eastern shore are the Elk, Chester, Choptank Nanticoke, Wicomico, and Pocomoke rivers. There is very little urban development around these rivers. Elkton is at the headwaters of the Elk, Cambridge is near the mouth of the Choptank, and Salisbury is near the headwaters of the Wicomico.

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*"Economic Base Study, Chesapeake Bay Drainage Basins", FWPCA, Middle Atlantic Region, Contract No. PH 186-63-92 (1967), p 94.

TABLE H-1. POPULATION OF POLITICAL JURISDICTIONS ADJACENT TO THE CHESAPEAKE BAY

Jurisdiction	Population		Increase, percent
	1950	1960	
	Maryland		
Western Shore			
Anne Arundel County	118,392	206,634	76.0
Baltimore City	949,708	939,024	-1.1
Baltimore County	270,273	492,428	82.2
Calvert County	12,100	15,826	30.8
Cecil County	33,356	48,406	45.1
Harford County	51,782	76,722	48.2
St. Marys County	29,111	38,915	33.7
Subtotal	1,463,722	1,779,042	21.5
Eastern Shore			
Dorchester County	27,815	29,666	6.7
Kent County	13,677	15,481	13.2
Queen Annes County	14,579	16,569	13.6
Talbot County	19,428	21,578	11.1
Somerset County	20,745	19,623	15.4
Subtotal	96,244	102,917	6.9
Regional Total	1,559,966	1,881,959	20.6
State Total	2,343,001	3,100,689	32.3
Percent of Total in Region	66.6	60.7	
	Virginia		
Accomack County	33,832	30,635	-9.4
Gloucester County	10,343	11,919	15.2
Hampton City	61,010	89,258	46.3
Isle of Wight County	14,906	17,164	15.1
Lancaster County	8,640	9,174	6.2
Mathews County	7,148	7,121	-0.4
Middlesex County	6,715	6,319	-5.9
Nansemond County	25,238	31,366	24.3
Newport News City	42,358	113,662	38.2
Norfolk City	213,513	304,869	43.3
Norfolk County	99,937	51,612	-48.4
Northampton County	17,300	16,966	-1.9
Northumberland County	10,012	10,185	1.7
Princess Anne County	42,277	77,127	80.1
Portsmouth City	80,039	114,773	43.4
York	11,750	21,583	83.7
Regional Total	684,998	913,733	33.4
State Total	3,318,680	3,966,948	19.5
Percent of Total in Region	20.6	23.0	

Source: U.S. Census, 1960.

The eastern shore was geographically isolated until the completion of a cross-bay bridge in 1958. The new bridge has improved access to this area but has not caused a substantial increase in land values or intensified land use patterns. Water pollution surveys have been conducted on the Wicomoco, Pocomoke, and Nanticoke rivers by the FWPCA; and on the Choptank, Chester, and Elk rivers by the State of Maryland. Some localized problems have been identified (e. g., some industrial pollution on the Upper Elk River), but there are no areas where large quantities of pollutants are being absorbed. *

Northwestern Shore

The northwestern shore of Chesapeake Bay is the critical pollution area because of the urban-industrial complex of Baltimore, and adjacent suburban environs. The primary drainage basins in this area are the Patapsco, Back, Gunpowder, Bush, and Susquehanna rivers. The Patapsco and the Back rivers are the most intensely developed of the river basins in this area, with the Baltimore industrial and harbor complex in the former, and high-density suburban development and municipal waste treatment facilities in the latter.

Back and Patapsco Rivers. The upper portion of the Back River is polluted by inflow from Herring Run and Moores Run. Pollution is caused by septic tank overflow (Moores Run) and industrial waste according to a Public Health Study Report on pollution of Back River. ** In 1965, it was estimated that Herring Run contributed 90 percent of the coliform and fecal coliform bacteria to the Back while four tributary streams and the Back River sewage treatment plant contributed 10 percent. *** The Parapsco River receives diluted waste from Gwynns Falls and Jones Falls. **** A Baltimore County Department of Health report, "Completed Water and Sewer Projects", January, 1968, indicated that 127 sewage improvements on Herring Run and 1,370 on Back River were completed as of January 26, 1968. A comparison report, "Baltimore County Sewer and Water Priorities", indicates that 1,606 other properties on Back River have either sewer, water, or combined problems. *****

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*Immediate Water Pollution Control Needs, The Eastern Shore of Delaware, Maryland, and Virginia, FWPCA Working Document No. 20, Middle Atlantic Region, September 1967.

**Ira L. Whitman, Physical Conditions of Streams in Baltimore and Their Relation to Park Areas, Report to Departments of Recreation and Parks, and Public Works, Baltimore, Maryland (1966), p. 33.

***P. R. Farragut, A Reconnaissance Study of the Chesapeake Bay, Regional Planning Council, Baltimore, Maryland (September, 1968) p 62.

****I. Whitman, op. cit., p 37.

*****P. R. Farragut, op. cit., p 62.

The Bush River. Studies of water quality in the Bush River by the Harford County Health Department have shown a substantial improvement from 1965 to 1967. This improvement in water quality is probably due to improved sewage treatment at the Edgewood Arsenal sewage treatment plant and the construction of a temporary stabilization pond to hold outflow until the county's Sod Run treatment plant is completed. In December, 1967, the FWPCA collected a small number of samples and found the streams around the Aberdeen Proving Ground in Harford County to be rich in nutrients but in no case was the water found to be unsuited for water contact recreation. The report suggested that a more detailed sanitary survey was needed in certain areas, however. *

Beaches Around Baltimore. During the summers of 1966 and 1967, 10 of the 21 county beaches were closed because of water quality problems. All 4 county-owned beaches at Bear Creek were closed because of untreated sewage, largely coming from Bethlehem Steel Corporation and Baltimore Harbor. In 1969, Bethlehem will tie into the county sewer system. Two of the three beaches on the Bird and Gunpowder rivers were closed primarily because of septic tank overflow. Beaches on the bay front generally have good water quality. Even if industrial and municipal waste is all treated, the very presence of the harbor traffic around Baltimore may continue to keep water quality at many beaches below levels acceptable for water contact recreation. **

Need for Public Facilities. The FWPCA has tabulated immediate construction needs for the northwestern shore area. They estimate that these facilities would cost $69 million (Table H-2). In general, however, water-quality information does not indicate a serious pollution problem, even in the outer harbor of the Patapsco. Of greater concern has been the problem of sludge disposal from sewage treatment plants in the Baltimore City area because of odor, nuisance, and lack of suitable sites for land disposal. Various proposals have been made, including barging or piping to the sea and incineration. Disposal at sea would be expensive: incineration would create an air-pollution problem.

Southwestern Shore

The southwestern shore of the Chesapeake Bay is drained by the Patuxent, Potomac, Rappahannock, York, and James rivers. The Potomac and the James rivers receive large quantities of municipal and industrial waste and have been studied extensively.

Patuxent River. The sewered population on the Patuxent is around 78,000. This causes few pollution problems though high coliform counts have been taken in some areas. ***

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*This section is taken from Paul R. Farragut, A Reconnaissance Study of the Chesapeake Bay, Regional Planning Council, Baltimore, Maryland (September, 1968).

**News Release, Baltimore County Department of Health (May 11, 1967).

***Cronin, op. cit., p 143-144.

TABLE H-2. IMMEDIATE CONSTRUCTION NEEDS, NORTHWESTERN SHORE CHESAPEAKE BAY

Location	Responsibility	Need	Cost, dollars
Patapsco sewage treatment plant	Baltimore City	Add primary capacity, add secondary treatment	10,000,000
Back River sewage treatment plant	Baltimore City	Add capacity and rehabilitate plant. (Includes outfall and pumping station at Moore's Run.)	20,000,000
Patapsco interceptor	Anne Arundel County, Baltimore County, Howard County	Eliminate waste discharges into Patapsco River, divert Patuxent Basin sewage.	4,500,000
Oliver Beach interceptor	Baltimore County	Divert sewage flows from Gunpowder River to Back River sewage treatment plant.	1,100,000
Interceptors and pumping stations for: Gray Manor Chesaco Park Pennwood Terrace Old Battle Grove Hyde Park Stansbury Manor	Baltimore County	Divert sewage leaking to Back and Middle Rivers to Back River sewage treatment plant.	2,100,000
Cox Creek sewage treatment plant	Anne Arundel County	Add to capacity and provide secondary treatment.	3,500,000
Marley Neck interceptor	Anne Arundel County	Construct a parallel force main to Cox Creek sewage treatment plant to increase capacity.	600,000
Edgewood-Sod Run interceptor	Harford County Metropolitan Commission	Divert sewage from Edgewood Arsenal sewage treatment plant to Sod Run sewage treatment plant.	2,750,000
Perryman-Sod Run interceptor	Harford County Metropolitan Commission	Divert sewage from temporary Perryman sewage treatment ponds to Sod Run sewage treatment plant.	800,000
Bel-Air Long Bar Harbor interceptor	Harford County Metropolitan Commission	Divert Bel Air sewage to sewage system serving Sod Run sewage treatment plant.	3,000,000
Swan Creek sewage treatment plant	Harford County Metropolitan Commission	Interim secondary treatment.	350,000
White Marsh interceptor	Baltimore County	Divert sewage from the upper Gunpowder River Basin to Back River sewage treatment plant.	900,000
Jones Falls pumping station	Baltimore City	Increase capacity to eliminate discharge of raw sewage to Jones Falls.	750,000
Port Deposit	Port Deposit	Provide secondary treatment.	150,000
Herring Run interceptor	Baltimore City	Add capacity to eliminate raw sewage discharges.	300,000
Southwest diversion sewer	Baltimore City	Eliminate sewage discharge into Gwynns Falls.	10,000,000
Lilly Run sewer separation	Havre de Grace	Separate sanitary and storm sewage for existing combined system.	500,000
Community interceptors at: Bynum Run Wildcat Branch Winter's Run Little Gunpowder Cranberry Run addition	Harford County	Divert untreated or inadequately treated sewage to Sod Run to protect respective streams.	2,500,000
County Line interceptor	Anne Arundel County, Howard County	Eliminate waste discharges into Deep Creek, provide capacity for diversion of Patuxent sewage.	3,000,000
Conowingo	Cecil County	Add secondary treatment.	30,000
Havre de Grace sewage treatment plant	Havre de Grace	Add secondary treatment.	300,000
Separate sewage	Baltimore City	Complete separation of storm and sanitary sewage.	1,000,000
Cooper Branch sewage treatment plant	Baltimore County	Eliminate plant by connecting to Patapsco interceptor.	250,000
Forge Heights sewage	Baltimore County	Interceptor to divert sewage to Forge Heights sewage treatment plant.	700,000
Total			69,080,000

Source: Immediate Water Pollution Control Needs, Northwest Chesapeake Bay Area, CB-SRBP, Working Document No. 19, FWPCA, Middle Atlantic Region, Aug., 1967.

A study was conducted to determine the temperature response of the river from thermal discharges at a proposed power plant to be built at Chalk Point. On the basis of an input of 100 billion Btu per day there would be a 1.47-degree-Fahrenheit increase in water temperature 1,000 yards from the discharge point. It was estimated that 7 percent of the heat discharge must be removed to decrease the 1,000-yard downstream temperature increase by 0.1 degree Fahrenheit. *

Potomac River. The Potomac River assimilates most measureable water-quality contaminants before reaching the Chesapeake Bay. It is presently handling 140,000 pounds of 5-day BOD per day. Annual contributions of 8,000,000 pounds of phosphorus and 25,000,000 pounds of nitrogen have been measured from Washington, D. C. Waste loadings are expected to double in the next 30 years and will be the major problem confronting the Potomac River basin. ** It has been estimated that the waste-discharging facilities in the Potomac estuary remove about 50 percent of their raw waste before dumping it into the river, resulting in many local pollution problems. ***

James River. Major waste loadings occur at Richmond and at Hopewell. Overall BOD removal in the upper estuary is estimated to be about 390,000 pounds per day. The economic value of the assimilative capacity of the James River is estimated to be $570,000 per year. This value is based on the addition of secondary facilities to existing primary treatment plants with an associated cost of BOD removal of $0.04 per pound. ****

COMMERCIAL SHIPPING IN THE CHESAPEAKE

The Chesapeake Bay is the gateway to Baltimore and five ports in Virginia. The total number of vessels handled annually by these ports is around 48,000 making it the second most heavily traveled bay on the East Coast (the Port of New York and New Jersey ranks first), and the third largest ocean port area in the country New Orleans ranks second in vessels handled). ***** Chesapeake Bay ports have a total of 157 terminals with drafts of over 6 feet. In addition to the vessels handled by the ports, there is a large volume of through traffic using the Intracoastal Waterway System which extends the length of the Bay, through Hampton Roads and into Virginia. The port of Baltimore handled around 12,000 vessels carrying 44 million tons of cargo in 1966. A $67 million, 10-year expansion program has recently been approved to construct up to eight new berths, rehabilitate obsolete berths, and acquire waterfront property. This 10-year expansion program is designed to provide the Port with facilities for the handling of containerized cargo. The completion of the Chesapeake and Delaware Canal Project will reduce the travel time from New York Harbor and Northern European ports by approximately 20 hours.

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*Appendix G.

**M. Brehmer, "Nutrients", Problems in the Potomac Estuary, Proceedings, Interstate Commission Potomac River Basin (1964), pp 47-50.

***Appendix G.

****Appendix G.

*****"The Economic Impact of United States Ocean Ports", U. S. Department of Commerce, Maritime Administration (data from 1963).

The Virginia ports are located at Alexandria, Norfolk, Newport News, Hopewell, and Richmond. Norfolk is by far the largest port in Virginia, handling annually approximately 39 million tons of cargo carried by 19,000 vessels. Newport News is second, handling 11,500 vessels and 14 million tons (Table H-3).

TABLE H-3. VOLUME OF TRADE IN MARYLAND AND VIRGINIA PORTS (1966)

Port	Cargo Tonnage million tons	Passengers(a)	Total Vessels(b) Handled
Maryland			
Baltimore	44	166,000	12,240
Virginia			
Alexandria(c)	0.5	--	1,067
Norfolk	39	61,200	19,342
Newport News	14	1,900	11,554
Hopewell	0.5	800	1,187
Richmond		800	2,205

Source: "Waterborne Commerce of the United States," Calendar Year 1966, Part I, Atlantic Coast, Corps of Engineers.

(a) Total inbound and outbound.

(b) Average of inbound and outbound.

(c) Data for 1963.

Port Development in Baltimore

Since the port of Baltimore came under public ownership ten years ago, it has been expanding its general cargo and containerized cargo facilities. Prior to this time, the vast majority of the port facilities were for handling bulk commodities, such as grain, coal, and ore which were owned by the railroads serving Baltimore. Since the port has been publicly owned, the Port Authority has spent approximately $50 million to develop facilities, and expects to spend $67 million over the 1967-1977 period to construct eight new berths, rehabilitate some existing berths, and acquire waterfront property. Thus, the Port Authority is committed to maintain the growth of port facilities in Baltimore. For the port to grow, access routes must be provided for an increase volume of traffic and deeper draft vessels. Most of the dredging activity in the Chesapeake Bay is centered around access routes to Baltimore. At the present time, the main access route is around Cape Charles at the tip of the Delmarva Peninsula and north to Baltimore. The disadvantage of this route, from the standpoint of the Baltimore Port Authority, is that their customers can gain 40 hours round-trip travel time by stopping at the Hampton, Virginia docks at the mouth of the Bay.* Deepening of the Chesapeake Delaware Canal to connect the Bay with the Delaware River will make travel time to Norfolk and Baltimore equivalent for southbound vessels. At the same time, studies to deepen the Chesapeake Bay channel are underway. The present project depth is 42 feet.

Dredging Chesapeake Channels

The least expensive place to dump spoil material from channel dredging is overboard and adjacent to the channel project. General practice has been for public or private groups requesting the project to provide land areas to serve as dumps. Land areas have been in short supply because of more intense utilization and because the sediments in the Chesapeake Bay are unconsolidated and have little use as fill material for land development. Subsequently, the Corps of Engineers has been using overboard spoil areas and has been criticized by commercial fishing and conservation groups of damaging the natural habitat.

In 1966, 4.7 million cubic yards of material was dredged from harbors and channels around the Chesapeake Bay by the Corps in the conduct of 20 dredging projects. In 11 cases, the spoil area was specified, and in 7 of these spoil was deposited overboard.** The spoil from the Baltimore Harbor Maintenance Project is deposited overboard in a canyon near Kent Island. A request has been made to extend this dump southware but conservation-oriented groups have opposed this proposal because of anticipated damage to fishing and to oyster beds.

Spoil from the Chesapeake and Delware Canal project has been dumped overboard adjacent to the channel. This has met with objections from the Maryland Board of Natural Resources who initially wanted the material dumped on-shore, and then later suggested using a deep trench near Pooles Island. The Corps has objected to the Pooles Island dump because of the high cost of moving material to that area.

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*Speech by Gregory Halpin on Impact of the Marine Shipping Industry on the Chesapeake Bay, delivered to Governor's Conference on Chesapeake Bay, Wye Institute, Chester-on-Wye, Maryland, September 12, 1968.

**Appendix E, Table E-5.

Studies have been conducted by the Corps to show that overboard disposal does not harm nursery areas in the upper Bay. The Natural Resources Institute at the University of Maryland has studied the effects of high silt load due to overboard disposal. They have identified very little effect on plants and animals in the water and on adult fish held in cages near the outflow or caught near the area. Some bottom animals were smothered but this was restricted to the area of deposition.

Though the quality of dredged material is poor, it has been successfully used as land fill in some cases. Many of the dock areas in the Baltimore Harbor are on dredged material. Also, a spoil island has been created as a wildlife refuge and proposals have been made to use spoil material for additional development of this kind (particularly south of Havre de Grace).

COMMERCIAL FISHERIES

Chesapeake Bay is probably best known throughout the nation and the world for its seafood resources. The economic and social values of commercial fishing on Chesapeake bay has been recently discussed by the director of the Department of Chesapeake Bay Affairs, using data and statistics from the Bureau of Commercial Fisheries, Department of the Interior, and the Department of Chesapeake Bay Affairs.* The material presented herein draws heavily upon this paper which pertains only to the Maryland portion of the Bay. Although similar data exist for the Virginia Bay resource, there are no references available in which the topic has been discussed as a whole.

The landed value of Maryland's commercial fisheries products reached an all-time high of $17 million in 1967. The 1967 value was distributed among species as follows: 66 percent in oysters, 14 percent in crabs, 9 percent each in soft clams and finfish, and 1 percent each in hard clams and all others. The value of Maryland's manufactured fisheries products in 1965 was $36 million and is estimated at more than $40 million for 1967.

About 9,000 fishermen, of whom two-thirds have no other employment, harvest Maryland's seafoods. Approximately 6,500 boats are used in harvesting and transporting the catch. The value of landings reached a low in 1963 and since then has been increasing at a rate of about $1.5 million a year. The harvests in 1965, 1966, and 1967 exceeded in quantity those of any year since 1908 (Table H-4).

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*By Joseph Manning, Director, Maryland Department of Chesapeake Bay Affairs, presented by Fred W. Sieling at the Governor's Conference on Chesapeake Bay, Wye Institute, Cheston-on-Wye, Maryland September 12, 1968. Soon to be available in in Conference Proceedings.

TABLE H-4. MARYLAND FISHERIES STATISTICS

1880-1967

Year	Thousands of Pounds	Thousands of Dollars
1880	95,712	5,222
1890	143,905	6,019
1901	82,975	3,768
1908	113,796	3,306
1920	59,531	4,198
1930	71,099	3,985
1940	51,085	2,598
1950	67,092	8,888
1960	69,113	13,963
1961	66,492	12,778
1962	67,574	11,926
1963	55,457	10,748
1964	70,828	11,729
1965	86,672	13,220
1966	82,704	14,012
1967	73,412	16,913

Source: By Joseph Manning, Director, Maryland Department of Chesapeake Bay Affairs, presented by Fred W. Sieling at the Governor's Conference on Chesapeake Bay, Wye Institute, Cheston-on-Wye, Maryland, September 12, 1968. Soon to be available in Conference Proceedings.

The number of wholesale and manufacturing establishments in Maryland has declined steadily from 357 in 1957 to 285 in 1965, while the number employed by these establishments has remained fairly constant. The decrease in number of establishments follows a general trend of consolidation in the food processing industry. Many small seafood processing plants have gone out of business in the past 30 years because of increased costs resulting from improved sanitation standards.

Oysters

Maryland and Virginia have been the leading oyster producing states for the past 2 years (Table H-5). Landed value of the Maryland harvest in 1966 was $7.8 million: the Virginia harvest was valued at $6.7 million. These two states accounted for more than 50 percent of the total value of production and 41 percent of the poundage.

TABLE H-5. PRODUCTION OF OYSTERS BY STATE DURING 1966. (FIGURES FROM U.S. FISH AND WILDLIFE SERVICE, BUREAU OF COMMERCIAL FISHERIES).

State	Pounds	Value, dollars
Maryland	12,068,785	7,861,846
Virginia	9,232,821	6,741,326
Washington	7,835,300	2,050,000
Texas	4,725,000	1,837,600
Louisiana	4,622,686	1,944,995
Florida	4,291,900	1,343,000
South Carolina	2,614,816	1,066,734
Mississippi	2,235,385	597,324
Alabama	1,304,314	606,538
California	737,362	432,936
North Carolina	724,265	398,884
New Jersey	669,043	765,087
Connecticut	336,100	675,371
Oregon	185,000	55,000
Georgia	181,861	63,563
New York	176,603	325,860
Massachusetts	62,800	162,639
Delaware	45,066	35,518
Maine	4,118	4,972
TOTALS	52,117,000	26,162,000

The tidal waters of the Chesapeake provide an excellent environment for oyster production. The salinity range of Maryland's portion of the Chesapeake Bay excludes the starfish, which is one of the oyster's most effective predators, and boring snails are restricted to the lower eastern shore. Two natural predators, the oyster parasite Minchinia nelsoni (MSX), and a marine fungus Dermocystidium marinum, are present in about one-third of the Bay's waters and have caused extensive mortalities.

The productivity of the oyster beds has declined during the last 100 years because of over-exploitation, neglect, and mismanagement. Since 1961, Maryland has invested about $3.3 million annually in an effort to restore the productivity of this resource. The effort has been based on (1) use of shell deposits that have accumulated in Chesapeake Bay over the centuries as oyster clutch and (2) the application of "farming" practices to the management of the oyster bars. Between 3 and 4 million bushels of dredged shells have been planted annually since 1961 in the several state seed areas.

Legislation enacted in 1967 and 1968 by the Maryland General Assembly provides a basis for placing the public oyster fishery of the state on a self-sustaining, nonsubsidized basis. A Fisheries Research and Development Fund was created in 1967, to be administered by the Department of Chesapeake Bay Affairs and to be expended for "repletion of fisheries resources, marketing of fisheries products, and related research". The Fund, which may be used to match Federal funds available for similar purposes, receives most of the revenues collected under the provisions of Article 66C relating to tidewater resources including royalties paid for shells, taxes, fines, license fees, sales of seed oysters, etc. The Department may also sell up to 50 percent of all seed oysters produced annually in excess of one million bushels to private planters. The 1968 General Assembly enacted a new schedule of oyster taxes which can be expected to yield revenues well in excess of $600,000 annually.

Blue Crabs

The blue crab catch fluctuates widely from year to year. Harvests in 1965 and 1966 exceeded those of any previous year for which records are available (back to 1880). Virginia leads Maryland in production of blue crabs while their combined catch is about 50 percent of United States production of this specie. Maryland's secondary position in crab production is partly attributable to more stringent controls over gear and season. Significant quantities of crabs are taken in Maryland by noncommercial crabbers, but no reliable statistics are available on the size of the catch.

Soft Shell Clams

Chesapeake Bay northward from the Little Choptank on the eastern shore and from the Potomac on the western shore is near the southern limit of the range of soft shell clams. The high water temperatures of late summer approach the critical upper limit for the species, but only one widespread mortality of serious proportions is known to have occurred during the past decade.

Before 1952, about 95 percent of the United States catch of soft shell clams was taken and marketed in the New England states. Introduction of the escalator harvester in Maryland, making possible the exploitation of subtidal populations of clams, occurred almost simultaneously with the beginning of a long period of decline in New England supplies. By 1962, Maryland was accounting for more than 70 percent of the total catch. Since 1964, however, New England supplies have increased, reducing Maryland's proportion of the total catch to 59 percent in 1966 (Table H-6). Future growth of Maryland's soft shell clam fishery appears to depend on increased demand for the product, the status of New England supplies, and geographic expansion of the fishery within Maryland's tidal waters.

TABLE H-6. PRODUCTION OF SOFT SHELL CLAMS BY STATE DURING 1966

State	Quantity, thousands of pounds	Value, thousands of dollars
Maryland	7,007	1,650
Maine	3,008	1,387
Massachusetts	1,039	676
Virginia	398	87
New York	282	86
New Jersey	72	29
TOTAL	11,806	3,964

Source: U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries

Finfish

Maryland leads the United States in production of striped bass. The catch usually accounts for about one-third of the total value of Maryland's catch of finfish. It reached an all-time high of 5.4 million pounds in 1961, and has averaged 3.5 million pounds annually since that year. About 60 percent of the catch is taken during the spawning run when the fish are concentrated in the tributaries and highly vulnerable to capture by gill nets.

Maryland's commercial finfishery has undergone a profound change during the past 20 years. Fishing effort has shifted from expensive gear such as pound nets and haul seines to relatively inexpensive gill nets. Many full-time fishermen have turned to other employment to be replaced by more than an equal number of seasonal fishermen, operating almost exclusively during the striped bass spawning season. Decreases in catch of valuable migrant fishes such as bluefish, flounder, croaker, and spot are attributable not only to decreased availability but to changes in methods of fishing. There is no indication that the trend will be reversed.

The value of Maryland's sports fishery is undetermined, but it is believed that its contribution to the economy of the state is many times that of the commercial finfisheries. An extensive creel census conducted in 1962 as a joint effort of the Chesapeake Biological Laboratory and the Department of Chesapeake Bay Affairs provides the basis for an estimate that sports fishermen probably catch more than twice as many striped bass as are taken by commercial fishermen.

Because of the conflicts between sports fishing and commercial fishing interests, and because commercial fishing effort is severly restricted by the laws of the state, there appears to be little likelihood that Maryland's commercial production of finfish will increase significantly.

SHORE EROSION*

Shore erosion is a problem to the entire Chesapeake Bay shore, but only the Maryland portion has received comprehensive study. In any future study of this problem, it would be desirable to include all of the Chesapeake shore because the deposition and erosion of material in all areas is interdependent.

Shore erosion results in destruction of property and filling of navigation channels. The study conducted by Slaughter specified the quantity of shore erosion by Maryland county. Over a 90-year period, Maryland has had a net loss of 24,712 acres or 274 acres per year. This loss is slightly more severe on the eastern than on the western shore. The islands, with 19 percent of the total measured shoreline on the Bay, suffered 31 percent of the net acreage loss. Most of the land lost on the eastern shore has been marshland with little economic value. Lands lost on the western shore have been of higher elevations and greater value for development purposes.

Slaughter identified those navigation improvement projects which were necessitated, at least in part, by shore erosion. Expenditures on these projects for new work and maintenance totaled $4 million. He estimated that $591,000 of the maintenance costs were directly attributable to deposition of shore-eroded material.

RECREATION

The most startling aspect of recreational development of the Chesapeake Bay is the lack of public development. This large body of protected water which seems physiographically well-suited to recreational pursuits is being used extensively for transportation, national defense activities, and commercial fishing. Reasons for this lack of public recreational development are both political and biological. It is used extensively for private recreation.

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*Turbid H. Slaughter, "The Shore Erosion Measurements", Bulletin 6, Shore Erosion in Tidewater Maryland (1949).

Political Restraints on Recreational Development

There has been very little interest among political subdivisions on the densely settled Western Shore of the Bay to make land available for high-density recreation. In an area where highly concentrated populations could make use of bay-oriented recreation areas, the land generally is held in private hands. This restricts access to a selected group of high-income users. It also permits selective exclusion of "undesirable" groups from using recreation facilities.

Biological Restraints on Recreational Development

Water around the Baltimore area is unsuited for water-contact recreation because of poor water quality. Industrial wastes are introduced in the immediate harbor area. Rivers around Baltimore are polluted with organic waste from sewage treatment plants, storm sewers, and septic tank overflows (discussed under Waste Assimilation).

Infestation of Bay waters by a stinging jellyfish, commonly referred to as the sea nettle, almost eliminates swimming during August in parts of the Bay. Researchers working on control measures have recently identified a natural enemy in the form of a native snail which eats the sea nettle larvae. Funds have recently been appropriated for further snail research and for research into other methods of control. *

Extent of Outdoor Recreation

Recreation on the Chesapeake Bay is centered around private summer and permanent residences, and private marinas. There is no information available on the number of recreation-oriented private dwellings on Bay locations but information on marinas has been collected. **

Recreational Boating. In 1965 there were 308 marinas in Maryland, all but 20 of these were located on the Chesapeake Bay or its estuarine tributaries. About 19,000 mooring slips were provided on waters with access to the Bay. The marina distribution throughout the state is presented in Table H-7. ***

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*Paul Farragut, op. cit. , p 53-54.

**Maryland State Planning Department, Maryland's Outdoor Recreation Plan, Interim Report, Baltimore (April, 1966), p. 28.

***See: Boating Almanac, 1968, Vol. 3, New York: G. W. Bromley and Company, Inc. Gale H. Lyon, Economic Analysis of Marinas in Maryland, unpublished doctoral dissertation, University of Maryland (1967).

TABLE H-7. NUMBER OF MARINAS, SLIPS, AND SLIPS PER MARINA, MARYLAND 1965

County	Marinas	Slips	Slips Per Marina
Anne Arundel	95	6,066	65
Baltimore (and Baltimore City)	50	3,261	65
Cecil	29	3,019	104
Calvert	17	932	58
St. Mary's	17	859	51
Queen Annes	10	808	81
Harford	11	795	72
Kent	17	737	46
Talbot	19	705	39
Charles	7	566	81
Dorchester	12	456	38
Prince Georges	2	456	228
Worcester	11	455	41
Somerset	3	208	69
Garrett	5	122	24
Wicomico	3	115	38
TOTAL	308	19,559	64

Source: Lyon, op. cit.

Note: The economic significance of Maryland's marinas is discussed in Appendix A of this report, "Impact of Marinas".

There are extensive data on recreational boat registration compiled by the Maryland Department of Chesapeake Bay Affairs and the U. S. Coast Guard. In 1967, Maryland registered over 62,000 recreational boats on the Chesapeake Bay, plus 1,200 to 1,500 documented yachts.* In Virginia, over 55,000 boats were registered, but these are not all in the Bay area.** There are also an estimated 20,000 craft using the Bay which are unregistered because they are powered by engines under 7-1/2 horsepower.*** On the basis of these figures it is estimated that there are approximately 120,000 recreational boats on the Chesapeake Bay. Ten thousand registered boats in Maryland are with owners residing out of the state, providing a significant inflow of expenditures to the state by recreational boaters.

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*Department of Chesapeake Bay Affairs, 1967 Boating Report, Annapolis.

**U. S. Coast Guard, Boating Statistics, 1967.

***Department of Chesapeake Bay Affairs, private communication.

Of the 66,000 registered boats in Maryland, 44,000 are kept on the water. There are about 19,000 marina slips available for public use, signifying that there are around 25,000 private water berths. In addition, 22,000 boats are kept at home and trailered to the point of launching. It is estimated that over 80 percent of these boats are used on the Bay.

Sport Fishing. The total sports finfish catch for the Bay is estimated to be three times as large as the commercial finfish cast (see Table H-8). The spending of sports fishermen in the Bay communities has a substantial economic impact on the local economies. There are no firm estimates on the contribution of the Bay's sport fishing

TABLE H-8. COMPARISON OF COMMERCIAL AND SPORTS FINFISH CATCH, CHESAPEAKE BAY, 1962

Species	Commercial Landings, pounds	Estimated Sports-fish Catch, pounds
Striped bass	3,910,000	9,340,000
White perch	1,960,000	7,300,000
Spot	27,000	81,000
Hardhead	5,900	2,400
Trout	194,000	2,200
Bluefish	63,000	1,200,000
Eels	114,000	268,000
Sunfish	22,000	46,000
Yellow perch	150,000	22,000
Catfish	297,000	170,000
TOTAL	6,743,000	18,400,000

Source: Elser, H. J., Chesapeake Bay Creel Census, 1962, Natural Resources Institute (1965).

activity to the local economies, but it is known that the number of participants throughout the Bay and the Maryland and Virginia tributaries is substantial.* A majority of boaters on the Bay use their craft, at least in part, for fishing.**

Promotional Activities. Fishing tournaments, sailing regattas, and power-boat races are organized for the enjoyment of the recreational boaters and observers in the Bay region. An annual "Chesapeake Appreciation Day" is conducted under the auspices of a regional association of yachtsmen and features races between the famed Maryland Skipjacks. Annapolis conducts an annual Clam Festival, which attracts thousands of visitors to that city. There is at least one biweekly newspaper, and one local radio station directed towards Bay-oriented recreational and commercial activities.

PLANNING FOR WATERFRONT DEVELOPMENT

To a large extent, waterfront and shoreline development on the Chesapeake Bay has been determined by the necessity and desire to develop the Bay for commercial fishing and shipping, recreation, and national defense. Future waterfront development will determine how these use patterns will change with the changing demographic and business environment of the Bay community. To illustrate how this change is now being accommodated, two projects have been selected for detailed discussion: the Baltimore Inner-Harbor Plan, and Anne Arundel County-Suburban Development.

Baltimore Inner-Harbor Plan

Background. On the Maryland portion of Chesapeake Bay, the hub of commercial activity is at the City of Baltimore. Baltimore has been a major shipping link between the Atlantic Coast and the Ohio valley for 150 years. Its commerce, as well as its seafood industry is dependent upon the estuarine resources of the Chesapeake Bay. The nation's largest steel mill and related ship yards are located adjacent to Baltimore at Sparrow's Point. The "Clipper Ships", which made the City of Baltimore known throughout the world, illustrate the city's historical ties with the Bay. The city's greatest historical event, the siege of Fort McHenry, was a battle to break the blockade of Chesapeake Bay.

Despite its historical and commercial ties with Chesapeake Bay, there is relatively little opportunity for Baltimoreans to be involved in waterfront related activities because the shoreline area is occupied by heavy industry and port development. The

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*Edgar H. Hollis, "Commercial and Sport Fisheries", Problems of the Potomac Estuary, Proceedings, Interstate Commission on the Potomac River Basin (1964).
C. E. Richards, "A Survey of Salt-Water Fishing in Virginia, 1955-1960", Chesapeake Science, Vol. 3, No. 4 (1962).

**Lyon, op. cit.

Inner-Harbor Plan is an attempt to make the waterfront more attractive and accessible.

The Plan's Objectives. The Inner-Harbor Plan is conceived as a joint private-municipal-federal venture to encourage interaction between the residents of the urban seaport and the Bay. The primary purpose of the Inner-Harbor Plan, as it typifies urban waterfront renewal on estuaries throughout the country, are as follows:*

(1) To renew the Inner-Harbor environment at minimum expense to the public.

(2) To eliminate the existing drain on the city treasury from blight and obsolescence.

(3) To create opportunities for enjoyment of the waterfront for persons of all ages, income, and backgrounds.

(4) To develop new downtown employment and business opportunities.

(5) To increase net tax returns to the city by $1. 5 million annually for a total municipal investment of $15 million.

(6) To create a new image for the city around the dramatic setting of the harbor.

New Harbor Facilities. The major features of the 110-acre project site will cover all aspects of the Bay environment. Baltimore's role as a major port of entry will be highlighted by construction of a World Trade Center, under the auspices of the Maryland Port Authority. A new marine museum will emphasize the city's historical importance as a maritime center. The Inner-Harbor will be closed off to commercial shipping, to accommodate recreational boating facilities in the heart of the city. This will include marinas, restaurants, and overnight "boatels". **

Other features to be included in the Inner-Harbor Plan are not, in themselves, directly related to waterfront activities, but will serve to attract people to the waterfront and its improved environment. These include a science center under the Maryland Academy of Science, extensive park areas, commercial recreation, apartments, religious facilities, office and commercial structures, and adequate parking facilities.

Harbor Environment. The Inner-Harbor and Charles Center project will transform downtown Baltimore into an environment of modern architecture and open space. At the same time, however, other environmental problems have not been dealt with. If present conditions prevail, the project will be attracting people to an area where little has been done to remedy serious air and water-pollution problems. ***

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*Inner-Harbor Project I Summary Fact Sheet, Inner-Harbor Management, Inc., One Charles Center, Baltimore.

**Appendix A.

***Dee, Horn, Sculley, and Weil, Report on the Inner Harbor, Baltimore, Maryland, The Johns Hopkins University Water Sciences and Management Program, Baltimore (1967), p 11.

Air pollution in the Harbor area is a nuisance and potential health threat. Water pollution is complicated by a lack of exchange of water between the Inner Harbor and the main harbor outside. Much of the water pollution of the Inner Harbor is attributable to municipal and industrial wastes derived from Jones Falls, the harbor's principal feeder tributary. Storm runoff from downtown Baltimore is also considered to be a major source of contaminants. *

The Inner Harbor report** suggests that pollution would have a deleterious effect upon the overall environment of the Inner Harbor, and thus on the redevelopment project. It recommends treatment measures be used to improve the quality of inflows from Jones Falls and storm drains around the harbor. While not prohibiting any of the planned functions at the site, the effects of oils, solids, industrial dyes and metallic wastes, coal dust, and organic pollution would significantly reduce the aesthetic appeal of the Inner Harbor Plan. Strangely, initial plans for the project had no concern for the possible detrimental effects of water pollution, nor was there any attempt in the plans to define what these effects would be.

Anne Arundel County-Suburban Development

Anne Arundel County, Maryland, on the west short of Chesapeake Bay, south of Baltimore, is unique because of its Bay-oriented activities. The county's only city is at Annapolis, a small metropolitan area of 30,000 people. The county differs from Baltimore in its Bay-orientation, for while the latter is using the public sector to stimulate new associations with the Bay, the former is doing so via the private sector.

Anne Arundel County contains 95 marinas, about 30 percent of Maryland's entire marina capacity, and about 10 percent of its population. *** It is a leading center for sail craft, a major seafood center, and the homes of the United States Naval Academy.

The county's privately-owned marinas are mostly in or adjacent to Annapolis. Most of the Chesapeake Bay shoreline and many smaller tributary estuaries in the county are dotted with private residential development with direct access to the Bay. There is one state park in the county which has a major bathing beach and several municipal beaches. By and large, however, the majority of shoreline in the county is private and recreational.

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*See: Chesley F. Garland, A Study of Water Quality in Baltimore Harbor, Publication No. 96, Maryland Board of Natural Resources (1952).
Stroup, Pritchard, and Carpenter, Final Report — Baltimore Harbor Study, Technical Report No. 25 (1961).
I. L. Whitman, Physical Conditions of Streams in Baltimore and Their Relation to Park Areas, Department of Public Works and Recreation and Parks, Baltimore (1966).

**Dee, et al., op. cit.

***Gale H. Lyon, Economic Analysis of Marinas in Maryland, unpublished Doctoral Thesis, University of Maryland (1967)

Limited Public Access. The growing popularity of boating has made property in Annapolis with Bay access extremely valuable. In addition to attracting people from Washington and Baltimore, the Annapolis area is now developing as a regional center for science and light industry, further taxing the boating facilities in the region and increasing the demand for new facilities.

Unlike the City of Baltimore, Annapolis and Anne Arundel County have few plans for public development of their waterfronts. Because of the great expanse of shoreline in the county, far more people can utilize the Bay and realize its amenities than in a limited area such as Baltimore. However, because of the predominance of private-shoreline development in the county, public access and use is limited for non-owners of waterfront real estate.

The City of Annapolis is aware that more public access to the waterfront is needed. Presently the city does not appear to have the resources to develop its own waterfront, particularly under conditions of land-value inflation. Thus, the majority of public activity towards waterfront development is determining patterns of use through zoning. They do have a capital improvement program, however, slated to spend $1.5 million by 1972 for more dock space and tourist facilities (Table H-9).* About 70 percent of these expenditures are to be city financed, the remainder will draw upon available state and federal funds.

PROVISIONS FOR OPEN SPACE ON CHESAPEAKE BAY SHORELINE

The bulk of this chapter has discussed the problems which have resulted from the interaction of Bay area residents and the natural resource base. The unique combination of land, rivers, and tidal bay waters which are naturally found in the estuarine zone have been developed intensively along the western and southern shores of the Bay. These areas are also valuable for wildlife and for recreation because of the sheltered land-water interface. The conflict between intensive and natural uses results from their inability to exist adjacent to each other under present conditions. Up until now, most of these conflicts have been settled in the marketplace. Lands have been purchased and developed in ways which are compatible with adjacent land-based activities. In the future, it is hoped that land development along the estuary will be planned to be compatible with the natural resources of the estuary. A survey conducted by the Battelle research team of the Baltimore and Virginia counties bordering the estuary revealed some agencies with very sophisticated plans, some with plans presently being developed, and others with no master development plans. Almost all of the counties responding to the survey are using some zoning procedures to regulate bay-shore development.

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*City of Annapolis, Capital Improvements Program (1968-1972).

TABLE H-9. PROPOSED WATERFRONT IMPROVEMENTS,
ANNAPOLIS, MARYLAND

Year	Project	Cost, dollars	City Contribution, dollars	Purpose
1968	Enlarge and improve City dock	200,000	50,000(a)	New mooring slips for visitors
1968	Acquire property, Compromise St.	225,000	225,000	Create new waterfront development
1969	Acquire remainder, and develop Compromise St. property	275,000	275,000	
1969	Public safety	25,000	25,000	Fire and police
1970	Complete city dock and market space plan	175,000	150,000	More waterfront development
1971	Start Bembe Point project	200,000	100,000(b)	Bay front development
1972	Bembe Point project and city marina	400,000	200,000(a)	Public recreation

Note: Contributions from other than city funds.

(a) State.
(b) Federal.

Source: Capital Improvements Program. City of Annapolis, 1968.

Western Shore Planning Agencies

The counties of Baltimore, Anne Arundel, and Harford are high population-density counties surrounding the Baltimore Metropolitan Area. These counties are concerned with the development of port-oriented industry. A 1965 inventory of vacant industrial land in Baltimore County attempted to identify land that is accessible to water transportation.* Of the 8,200 acres of industrial zoned land vacant in Baltimore County, 21 percent or 1,690 acres has potential access to deep-water channels or to port facilities. The study found all of this land to be unsuitable for development in its present state because of a lack of drainage facilities. Most of the land being considered was marsh.

The preliminary master plan report for Patapsco Neck Planning Area includes attempts to coordinate intensive land use and open space in an "economical and desirable manner".** Patapsco Neck is a residential and industrial area between the confluence of the Back and Patapsco Rivers in Baltimore County. The plan attempts to provide a public elementary school on a large site to be used as a recreation center for every one to two thousand dwellings. In addition to the school playground parks, Patapsco Neck had 5.2 miles of shoreline for public recreation at the time that this preliminary report was prepared. An additional 2.8 miles were proposed, which would place 15 percent of the shoreline in this use. North of Patapsco Neck on the Chesapeake is the Eastern Planning Area of Baltimore County. A Report on the Master Plan and Comprehensive Rezoning Map for the area recommends the purchase of land for open space with bond issues. Two major parks are proposed along the waterfront: on the Hart Island Chain and Gunpowder-Dundee Park around Saltpeter and Dundee Creeks.

The plan proposes the construction of a causeway to Hart and Miller Islands, and the filling of 200 acres on Hart Island. The fill for the islands and the causeways is to come from a proposed channel-dredging project in the Black River. This development would give access to 8 miles of shoreline, doubling the recreational waterfront of Baltimore County.

The proposed Gunpowder-Dundee Park is a 1000-acre tract of woody, marshy, and cultivated land. The Plan suggests that some of this land is well-suited to providing a natural wilderness for the area. Most of this land is now privately held.

None of the Baltimore County areas discussed have a zoning classification for recreational or open-space use. Zoning codes are used to regulate the density of dwelling units, and the type of dwellings and industrial users which may locate in particular areas. Open space is being considered within the housing codes so that recreation areas will be available in areas of high-density housing. This type of zoning does not necessarily preserve waterfront areas which have unique recreation or wildlife value.

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*Land for Industry — An Inventory and Analysis of Vacant Industrial Land in Baltimore County, Maryland, Office of Planning and Zoning, Industrial Development Commission (October, 1965).

**Preliminary Master Plan Report, Patapsco Neck Planning Area, Office of Planning and Zoning, Baltimore County (1961).

The waterfront in Annapolis County is presently all zoned as a maritime district. The Planning and Zoning Commission has recommended that this zone be divided into (1) marina activities, recreational boating and apartments, and (2) boat building, bulk oil plants, seafood, and heavier maritime uses. The first zone only would include activities which are compatible with residential uses. There are no legal requirements for open space in the old ordinance nor are they being suggested in the proposed ordinance changes.

Eastern Shore Planning Agencies

In the Maryland Counties of Talbot, Salisbury-Wicomico, and Dorchester there are no formal plans for coastal development. Salisbury-Wicomico County is presently working on an open space and recreation plan, and they anticipate that the Stump-Point - Ellis Bay area will be designated as a natural shoreline area. Dorchester County has all Bay land zoned residential.

Plans for Open Space

Among those planning agencies who responded to Battelle inquiries, only one (Kent County) discussed the use of land for wildlife preservation and for undeveloped open space. In two counties there are large estuarine parks held by state and federal agencies (Cecil and Prince Georges counties). One of the plans for land use suggests a zoning classification to include recreation and small open spaces (Baltimore-Anne Arundel County Planning Area).

These general findings indicate a reluctance on the part of local planning agencies to designate land for low-intensity use compatible with undeveloped estuarine coastal areas. Almost the entire Chesapeake Bay shoreline is designated for private use. Local government agencies apparently are sensitive to the desires of private users of coastline and are not in a position to put this land to economically less productive functions. The few major parks which do appear on the coast have been in existence for a long time.

Rural Area Development. Though estuarine areas are not available for public use, the majority of lands adjacent to Chesapeake Bay are in rural development and will probably remain so for many years. Two factors are primarily responsible for this lack of development. First, there is resistence by landowners to change the use of the land and open the way for "outsiders" to come in. Secondly, these areas are relatively remote. Southern Maryland, located on the western shore of the Bay, and the Delmarva Peninsula are removed from the primary traffic arteries of the eastern megalopolis.

Availability of Federal Property. Several attempts are being made to gain public access to federal lands in the Bay. Discussions have been held to acquire a large piece of wooded acreage at Fort Howard for use as a park and beach. Also, Aberdeen Proving Grounds, located within easy access of Baltimore, has been viewed as a possible recreation area. At the present time, recreation facilities for employees are operated by the base but opening this area to the public is complicated by the dangerous nature of the work being carried out there. This land is a valuable wildlife habitat in its present state.

SUMMARY

The Chesapeake Bay and its tributaries have served as a focal point for settlement since the first colony was established around 1634. The community has benefited in many ways from its association with the estuarine environment. This Appendix has focused attention on three major uses: (1) assimilation of waste material, (2) avenues for transportation, and (3) nursery for the local fishery. In discussing these uses, problems have been identified which are presently creating conflicts between various groups around the Bay.

Problems identified are both man-made, such as water pollution and disposal of dredged spoil, and natural, such as shore erosion and sea nettle infestation. To maximize the economic benefit to the Bay community these problems must be dealt with in an orderly fashion via planning by public agencies on local and regional bases. A survey of planning agencies was conducted by Battelle to learn how plans are being developed in communities surrounding the Chesapeake. The results of this survey indicate that little consideration is being given to how the natural resources of the Bay can best be used by the Bay community. A counter example was discussed in some detail, however, namely, the Baltimore Inner Harbor Project which is an attempt to bring the people of the city into closer contact with the Bay environment.

APPENDIX I

NOTES ON COST-BENEFIT AND SYSTEMS ANALYSIS AS APPLIED TO THE ANALYSIS OF ESTUARINE POLICY

H. R. Hamilton

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APPENDIX I

NOTES ON COST-BENEFIT AND SYSTEMS ANALYSIS AS APPLIED TO THE ANALYSIS OF ESTUARINE POLICY

by

H. R. Hamilton

INTRODUCTION

The term "cost-benefit analysis" means different things to different people. To some it is viewed as a very general concept wherein increments of cost and benefits with regard to any investment, program, or policy are compared. For instance, Prest and Turvey state, "Cost-benefit analysis is a practical way of assessing the desirability of projects, wherein it is important to take a long view (in the sense of looking at repercussions in the future) and a wide view (in the sense of allowing for side effects of many kinds on many persons, industries, regions, etc.); i. e., it implies the enumeration and evaluation of all relevant costs and benefits"*. At the other extreme, cost-benefit analysis is viewed by many as essentially limited to the traditional economic analyses conducted by Federal agencies, such as the Bureau of Reclamation and, particularly, the United States Army Corps of Engineers, in relation to public investments in water resource projects. The discussion below assumes cost-benefit analysis is a general method of incremental economic analysis, although it is recognized that its applications have often been rather narrow. **

Historical Background

The term "cost-benefit analysis" has long had a close association with public investments in water resource analysis. The River and Harbor Act (1902) required a board of engineers to report on the desirability of Army Corps of Engineers' river and harbor projects, taking into account the cost and the benefits to commerce. Another act (1920) further required a statement of local or special benefits as a means of charging local interests with part of the cost. Consequently, the Corps of Engineers worked out valuation techniques confined to tangible costs and benefits.

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*A. R. Prest and R. Turvey, "Cost-Benefit Analysis: A Survey", The Economic Journal, No. 300 LXXV (December, 1965), p 683.

**Hammond states that even the Federal Government allows a wide latitude in the application of C/B technique: "Even the official formulas for Government use appear to recognize the right of individual agencies to vary their practices as conscience or convenience may require." R. J. Hammond, Benefit-Cost Analysis and Water Pollution Control, Food Research Institute. Miscellaneous Publication 13, Stanford University.

In the Thirties, with the New Deal, the idea of broader social justification for projects developed. The Flood Control Act of 1936 authorized Federal participation in flood control schemes "if the benefits to whomsoever they may accrue are in excess of the estimated costs". The practice of making these analyses then spread to other agencies concerned with water development projects. The purpose was not only to justify projects but also to help decide who should pay.

By the end of World War II, agencies had broadened their approaches by:

(1) Bringing in secondary and indirect benefits and costs

(2) Including intangibles.

In 1950, an interagency committee produced the "Green Book" - an attempt to codify and agree on general principles - which introduced the language of welfare economics. *

STANDARDS FOR COST-BENEFIT ANALYSIS

Senate Document No. 97, "Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources", further amplified and updated official procedures for water resource investment analysis in the United States. This document is divided into six sections: (1) Purpose and Scope, (2) Objectives of Planning, (3) Planning, Policies, and Procedures, (4) Review of Comprehensive Plans and Project Proposals, (5) Standards for Formulation and Evaluation of Plans, and (6) Relation to Cost Allocation, Reimbursement, and Cost-sharing Policies, Standards, and Procedures. Comments on several of these sections appear below.

Purpose and Scope. The document states: "The purpose of this statement is to establish Executive policies, standards, and procedures for uniform applications in the formulation, evaluation, and review of comprehensive river basin plans and individual project plans for use in development of water and related land resources.... These provisions shall govern, insofar as they are consistent with law and other applicable regulations, all formulation, evaluation, and review of water and land resources plans.

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*Prest and Turvey, op. cit., pp 683-684.

Any proposed variation from these policies and standards shall be specified in planning reports and the reasons therefore indicated. "* It is not stated in this document that estuarine projects and policies are considered within the preview of the procedures enumerated, but it is the opinion of this author that the provisions of Senate Document 97 are relevant to estuarine management policies and can be used until congress provides specific guidelines for these regions.

Planning Objectives. The document sets forth three purposes of planning: (1) economic development, (2) preservation, and (3) the well-being of the people. In planning for the well being of the people, "...care shall be taken to avoid resoure use and development for the benefit of a few or the disadvantage of many". * The intent of this section is to avoid public investment in water resources wherein the benefits accrue to only a small segment of the public or to special interest groups.

Planning, Policies, and Procedures. Section III states that "regional, state, and local objectives shall be considered and evaluated within a frame-work of national public objectives.... " and that "significant departures from a national viewpoint required to accomplish regional, state, or local objectives shall be set forth in planning reports...". ** The significance of this statement is that benefits derived from water policy and investment should be truly national in character and, if they are not, then their local nature should be clearly specified in planning reports. This is an important factor which will be discussed subsequently in relation to the kinds of benefits that may accrue from water resource programs.

Standards for Plans. Section V sets forth some of the details regarding the kinds of plans that are to be submitted in justification of water resource investments.

> It states: "Comprehensive plans shall be formulated initially to include all units and purposes which satisfy these criteria in quantitative economic terms:
>
> (a) Tangible benefits exceed project economic cost
>
> (b) Each separable unit or purpose provides benefits at least equal to its cost
>
> (c) The scope of development is such as to provide maximum net benefits
>
> (d) There is no more economical means, evaluated on a comparable basis, of accomplishing the same purpose or purposes which would then be precluded from development if the plan were undertaken. "***

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*Senate Document 97, p 1.

**Ibid.

***Ibid., p 8.

Item (a) is a familiar benefit-cost ratio. It should be noted that only tangible benefits can be counted in the formal benefit-cost ratio. It should also be noted that in recent years analyses have been made which include estimates for such benefits as recreation — benefits which are viewed by some as "intangible". Item (b) seeks to overcome a complaint that economists have had against certain applications of benefit-cost analysis by Government agencies wherein the projects were extended beyond the point where marginal costs equaled marginal benefits. *

Definition of Benefits

Benefits are defined in Section V as "increases or gains, net of associated or induced costs, in the value of goods and services which result from conditions with the project, as compared with conditions without the project. Benefits include tangible and intangibles and may be classed as primary or secondary."**

The problem of determining the true additions to national wealth resulting from water-resource investment is the basis for much of the controversy surrounding applications of benefit-cost analysis. Some of these problems are as follows:

(1) defining the economic conditions that would exist both with and without the project

(2) determining whether or not resources committed to the project would have been used somewhere else if the project was not initiated

(3) determining the economic return on alternative investment of the resources.

These problems are clarified somewhat in Senate Document 97 by more detailed definitions of the classes of benefits.

Tangible Benefits. Tangible benefits are defined as "those benefits that can be expressed in monetary terms based on or derived from actual or simulated market prices for the products or services, or, in the absence of such measures of benefits, the cost of alternative means that would most likely be utilized to provide equivalent products or services."*** As defined here, tangible benefits appear to be net increments to national wealth resulting from an investment that can be measured in monetary terms because of existing market prices for the benefits, or because a

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*See, for instance, Hammond, op. cit. p 14, footnote 28.
**Senate Document 97, p 8.
***Ibid

simulated or imputed market price can be derived.* For example, a sewage treatment plant may allow shell fishing to be conducted on a previously closed bed. The net value of the catch would be considered a net increment to national wealth. The investment in the sewage system would be responsible for the benefit stream. In addition, if an imputed value can be given to increased recreation enjoyment in the area, simulated market prices can be derived for the products.

Intangible Benefits. Intangible benefits are defined as "those benefits which are not fully measurable in monetary terms or capable of such expression in formal analysis."** This definition of intangibles is interesting, since it seems to imply that the difference between tangible and intangible benefits depends upon the "state of the art" of the economist's trade at any given point in time. Thus, if a method is found to impute prices or values to a heretofore considered intangible, it then becomes a tangible. It would appear that the incorporation of dollar values for recreation benefits into cost-benefit analyses may have marked a change in attitude of many people who previously considered recreation benefits intangible. As late as 1960, Hammond was skeptical about the relevancy of recreation benefits to cost-benefit calculations.***

Primary Benefits. Primary benefits are defined as "the value of goods and services directly resulting from the project**** less associated costs incurred in realization of the benefits and induced costs not included in project costs."***** This definition replaces the words "primary" with "directly" but does not describe the meaning ascribed to the word direct. However, there seems to be general agreement that primary benefits involve what might be the "main" purposes for which a project or system of projects are initiated. For instance, some of these main uses may be water supply, power, navigation, irrigation, etc. These uses are directed at producing goods of some kind. Here there is some "commodity", such as power or lower cost transportation, which can be evaluated in terms of being sold in one sense or another.

Secondary Benefits. The concept of secondary benefits denotes potential increases in income (and employment) which are "spun off" as a result of the primary benefits. Such benefits might "stem" from a project; e.g., the additional employment and income generated by a cannery that cans the fish from the additional fish catch attributable to a water resource investment or policy. Or the benefits might be "induced", such as the extra profits made by equipment manfacturers selling to the fishermen.*

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*McKean argues against the "net increment to national wealth" concept. He argues that "attention be focused on the increments rather than on large aggregates which reflect offsetting pecuniary effects." R. N. McKean, Efficiency in Government through Systems Analysis, (New York: J. Wiley and Sons, 1966), p 145.

**Senate Document 97, p 8.

***Hammond, op. cit.

****Note use of word "project", which illustrates the project rather than systems orientation that has been evident in Government applications of benefit-cost analysis.

*****Senate Document 97, p 9.

Analyses concerning secondary benefits have been the most controversial part of cost-benefit analysis.** Economists tend to agree that "secondary activities induced by a water resource project are, under conditions of full employment, likely to be off-set by decreases elsewhere in the economy".*** As a result, Ciriacy-Wantrup has recommended that such benefits be entirely excluded from consideration in cost-benefit analyses of public investments.****

In reviewing arguments of economists on the secondary benefit question, it is not clear whether they feel that such secondary benefits are nonexistent or whether they feel that measurement is too complex to undertake. For instance, Hammond argues that "if one is attempting an evaluation on a nationwide scale,... the case for excluding secondary benefits seems overwhelming, if only because once they are admitted there is no logical point down the endless chains of results at which one can halt".***** Certainly, the calculation of secondary benefits may be very difficult, but this cannot be used as an argument that they do not exist. In situations where resources, either physical or human, are idle, secondary benefits could well be substantial. Furthermore, national policy in recent years has focused on regions of the nation with above average unemployment levels of people and resources. While one may question the economic efficiency of such policies from the point of view of maximizing national wealth, the point is that such policies exist. In these cases, the "spinoff" benefits may be critical elements in project or program evaluations and must normally be estimated.

In many cases, it might be necessary to admit that the benefits estimated may be largely regional rather than national. Perhaps it is necessary to label them as something different from secondary benefits in order to emphasize that they are not truly national in character.

A review of the cost-benefit literature leads one to believe that many of the arguments about cost-benefit analysis revolve around the ways that it has been applied, rather than its ultimate usefulness. Arguments against the degree of accuracy with which things can be measured seem (as used by Hammond, for instance) non sequitur. In many cases some decision must be made. It is believed that it is better to make the decision based on informed quantitative judgments than upon qualitative assertions. Further, it appears that cost-benefit analysis is really little more than incremental economic analysis. Too much emphasis has been put on the fact that a cost-benefit ratio is calculated. If cost-benefit analysis is defined broadly, arguments against it seem to be arguments against economic analysis in general.

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*Prest and Turvey, op. cit., p 689.

**Hammond, op. cit., p 34.

***Hammond, op. cit., p 34.

****S. V. Ciriacy-Wantru[illegible] "Benefit-Cost Analysis and Public Resource Development", Journal of Farm Economics (Norvember, 1955), p 680.

*****Hammond, op. cit., p 34.

Application of Benefit-Cost Analysis

The increments of costs (including capital or investment costs) and benefits that are generated may result from the implementation of a policy as well as a public investment in "concrete or iron". One might make a cost-benefit analysis of a set of water-quality standards for an estuary. The costs involved would result from the investments and expenses needed to maintain the standards, and the benefits would result from the alleviation of water-use conflicts involving pollution. Thus, estuarine programs and policies might be evaluated by cost-benefit analysis, properly conceived and executed.

In the past, cost-benefit analysis has often been tied to specific water resource investment projects. For instance, the cost-benefit ratios are quoted for a dam in many Corps of Engineer's reports, even though the dam may be part of the comprehensive river basin plan. Unless various proposed dams within a basin are entirely independent in terms of the costs involved and the benefits induced, one would expect a whole range of benefit-cost ratios resulting from alternative configurations of the systems of dams recommended. * Or, one would expect a cost-benefit ratio for the entire system.

The above criticism of current uses of the cost-benefit method in no way impugns the ability of the methodology as applied to a total system. Senate Document 97 in no way says cost-benefit analysis must be tied to projects. In the real world, however, the evaluation of a complete system is much more difficult than the evaluation of a given project, particularly when project-oriented analyses are allowed to assume that the world external to the project remains constant. Clearly, however, programs, policies, and investments relating to estuaries must involve a systems-analysis approach, since most estuarine programs will have widespread ramifications across a number of estuarine uses. In light of this fact, the section below describes the rudiments of an estuarine model which might be useful in terms of applying benefit-cost analysis to estuarine problems. In this section cost-benefit analysis and systems analysis are viewed as identical. Systems analysis techniques are suggested merely as the means for generating the streams of costs and benefits as they would occur over time.

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*See: J. V. Krutilla, Sequence and Timing in River Basin Development, Resources for the Future, Inc., Washington, D. C. (February, 1960).

THE USE OF SYSTEMS ANALYSIS

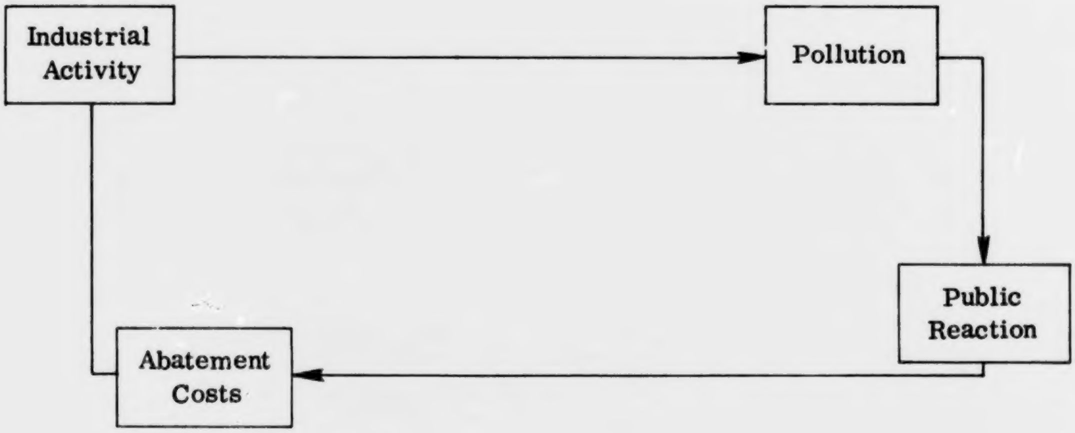
The term "systems analysis" has as many alternative meanings as does benefit-cost analysis. Basically, the concept of systems analysis merely denotes the inclusion of all significant variables relating to the topic under study within the framework of one analysis. Systems analysis attempts to approach a problem as a totality, recognizing interactive and mutually dependent characteristics of the problem.

In practice, systems analysis employs mathematical models and uses the computer as a tool. These circumstances occur because (1) most real-world systems cannot be subjected to experiment, whereas a mathematical model can be simulated, altered, etc.; (2) mathematical models are useful abstractions since they can relate more variables than the human mind can grasp; and (3) computers are low-cost means of experimenting with the models that are developed.

Design of Model

The management of most estuaries involves complex technical and economic relationships which are difficult to study in isolation. A systems analysis of these estuaries will include factors such as the physical flow of water in the estuary, the biological life in the estuary, the effects of various levels of pollutants on the biological life, the population in the region adjacent to the estuary, industrial development around the estuary, the transportation variables related to commercial shipping, and a host of other factors discussed in the main body of the report.

In addition to handling many interrelated factors, the system will involve relationships of a feedback nature. For instance, Figure I-1 shows what the systems analyst terms a feedback loop. Here the level of industrial activity in the region causes pollution. Pollution precipitates a public reaction, and the public reaction in



turn imposes costs on industry needed to reduce the pollution level. Finally, the costs imposed may affect further industrial location or expansion in the region, thus changing the level of economic activity from that which it would have ordinarily attained in absence of the public reaction.

A third technical feature concerns the fact that there is no reason to expect that the complex relationships involved in estuaries would be linear or independent of time.

Given these four factors – namely, large numbers of variables, feedback, nonlinearities, and time-variant functions – simulation is the only feasible approach by which we can explore mathematical models of estuarine situations. Subsequent to the initial formulation of simulation models which will aid in more rigorous definition and understanding of the systems involved, however, it might be possible to devise other kinds of models which provide "optimum" solutions to specific questions if we can define some criterion for judging optimality.

A systems model of an estuary would be useful in answering the following kinds of questions:

(1) How will the growth of economic activity around the estuary affect pollution loading ?

(2) What would be the effects on growth, pollution, biological life, and recreation in connection with a large port development project ?

(3) What might be the effect on a local fishery and its associated employment and incomes if we allow pollution to reach specified levels ?

(4) What would be the effect of regulation concerning land reclamation in an estuary on (a) fish and wildlife, (b) recreation, and (c) industrial and residential development ?

(5) What would be the effect on pollution and industrial development of removing a military establishment from a given estuary ?

(6) What might be the effect of oil production on the economy of an estuarine region and what conflicts might it create within the estuary ?

Other questions of the type listed above surely come to mind in light of the conflicts and trade-offs between estuarine uses discussed in the body of the report.

A number of different kinds of factors must be used in any systems model that is developed. It is convenient to separate these factors into two classes: variables and parameters. In the context of modeling, a variable may be roughly described as a quantity whose magnitude changes over the time-period of interest in the modeling analysis. In contrast to variables, parameters may be considered constant over the time period of interest in the analysis.

Type of Variables

The variables in a model may be further classified as endogenous and exogenous. An endogenous variable is one whose behavior over time results from its relationship with other variables in the model (both exogenous and endogenous). In contrast, an exogenous variable has a behavior that is prescribed in advance to model esperimentations. The values of the exogenous variables are not affected by the behavior of any of the other variables. Table I-1 lists some of the exogenous and endogenous variables, as well as several of the parameters, that might be included in an esturine model. It should be noted that whether a factor is an exogenous or endogenous variable or a parameter can only be determined in light of a given situation. Thus, the factors listed in Table 1 might be recategorized in specific situations.

TABLE I-1. EXOGENOUS AND ENDOGENOUS VARIABLES AND PARAMETERS OF A HYPOTHETICAL ESTUARINE SIMULATION MODEL

Exogenous Variables	Endogenous Variables	Parameters
General technology	Fish population	Water withdrawals by
Hydrological variables	Water quality	(1) Domestic users
National economic values and trends	Economic growth	(2) Industrial users
	Recreational benefits	(3) Others users
Estuarine policy, program and investment alternatives	Wildlife benefits	Water consumption by
	Land values	(1) Domestic users
	Water demand	(2) Industrial users
		(3) Other users

The construction of a simulation model for use in estuarine management is a major task. However, such a task is not without precedent. The study of the Delaware Estuary by the Federal Water Pollution Control Administration included a physical model of this estuary.* Taken as variables exogenous to this model were economic activity and resultant pollution loads, as well as projections of water use. Levels of pollution were then endogenously computed. Exogenous to the model were values of economic benefits to be gained. The model used was highly complex but limited to the physical characteristics of the estuary.

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*R. V. Thomann, "Use of Systems Analysis in Estuarine Water Pollution Control", New Horizons for Resources Research: Issues & Methodology, 1964, Western Resources Conference, University of Colorado Press, Boulder, Colorado (1965), pp 47-59.

A contrasting approach was utilized by Battelle in a study of the Susquehanna River Basin.* Here, an economic model was tied to a hydrologic model in an attempt to show interrelationships between the economy and the water variables. If one expects that the economy of an estuary will affect the estuary, as it must, and that the effects on the estuary may affect the economy, as seems highly likely in many situations, then a feedback situation exists and a systems model of the simulation type, like the Susquehanna model, may be warranted. Such models are not simply constructed. They require many tenuous assumptions. But they would make explicit our best knowledge about the complex, interactive estuarine systems, and their expense would represent only a small fraction of the economic values at stake.

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*H. R. Hamilton, et al, A Dynamic Model of the Economy of the Susquehanna River Basin, Battelle Memorial Institute (August, 1966).

APPENDIX J

ANNOTATED BIBLIOGRAPHY
ON
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on

ESTUARINE ECONOMIC STUDIES

INTRODUCTION

This bibliography was compiled for the purpose of providing detailed subject access to the literature on estuarine economics identified during the course of the project, "The Identification of the Economic and Social Importance of Estuarines in the United States", performed under Contract No. 14-12-115. The abstracts are slanted to reflect those aspects of the literature pertinent to estuarine economics; other aspects, not important to the project, are not necessarily covered. The subject index has the same orientation.

The abstracts are, for the most part, of the indicative type — intended to describe the content of the references (as they pertain to estuarine economics) without relating specific details. They are arranged in alphabetical order by first author or, in the case of anonymous articles, by the first significant word in the title.

The references listed in the bibliography have been indexed using the Water Resources Thesaurus*, and according to procedures compatible with those stated in the Instructions for Abstracting and Indexing Scientific and Technical Documents for the Water Resources Scientific Information Center**.

All index terms associated with each article are listed in the bibliography immediately following the abstract. The terms considered most descriptive of the central theme of the article are preceded by asterisks and printed in upper-case letters. The lower-case terms represent topics judged to be of secondary importance; they are presented for the convenience of those using the bibliography as input to information systems, or otherwise requiring in-depth indexing.

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*Water Resources Thesaurus, U. S. Department of the Interior, Office of Water Resources Research, Washington, D. C. (1966).

**Instructions for Abstracting and Indexing Scientific and Technical Documents for the Water Resources Scientific Information Center (WRSIC), U. S. Department of the Interior, Water Resources Scientific Information Center, Washington, D. C. (1968).

The format chosen for the subject index has been used before in the Battelle-compiled Bibliography on Socio-Economic Aspects of Water Resources, prepared in 1966 for the Office of Water Resources Research. It was chosen over alternative formats because it is particularly informative and affords the user a high degree of selectivity. Each entry consists of an alphabetically ordered index term, full title of the reference, and all other terms by which the article is indexed. The index's conventional arrangement overcomes the problems of user education and acceptance. By basing the index on those select few terms which best describe each reference (i. e., the terms printed in upper-case letters in the bibliography) an acceptable compromise between index depth and manageable size was achieved.

The index was produced on Battelle's CDC 6400 computer utilizing a modified Key-Word-Out-of-Context (KWOC) program especially prepared by Donald P. Moon, Information Scientist, Information Operations Division. Preparation of the bibliography and index was supervised by Donald H. Owens. Other personnel involved were Karen B. Barnes, Ann R. Glenn, Robert T. Niehoff, Victor D. Zoller, Nancy E. Drake, Richard E. Krohn, Myrtle W. Banas, Linda L. Stewart, and the authors contributing to this report.

ABSTRACTS

1. Aalto, Johan A., THE POTOMAC ESTUARY - STATISTICS AND PROJECTIONS, paper presented at Winter Meeting of the Interstate Commission on the Potomac Basin, Fredericksburg, Virginia, February 29, 1968.

   The author presents information water quality and polution loads in the Upper Potomac Estuary. The total load is eight times the assimilative capacity required to maintain a dissolved oxygen (DO) average of five mg/1. The median counts per 100 ml at Woodrow Wilson Bridge were 91,000 MPN coliforms and 24,000 MPN fecal coliforms (E. Coli). Minimum dissolved oxygen levels for 1965 and 1985 are also given.

   *STATISTICS, *WATER QUALITY, *BIOCHEMICAL OXYGEN DEMAND, *DISSOLVED OXYGEN, *FORECASTING, *WATER POLLUTION, E. Coli, data collections, oxygen demand, plants, coliforms, bacteria, microorganisms, Maryland, Virginia, geographical regions, regions, Appalachian Mountain region, Atlantic coastal plain, coastal plains, northeast U. S., southeast U. S.

2. Aasen, K. D., SUMMARY OF THE 1963 AND 1964 SOUTHERN CALIFORNIA INSHORE BAIT FISHERY, California Fish and Game, Vol. 53, No. 1, 1967, pp. 28-34.

   The distribution, method of catch, and the 1963 and 1964 catch statistics are given for the most commonly taken Southern California inshore bait species. The author states that the 180,000 pounds per year (valued at $90,000) is adequate to supply the needs of the sport fishermen at this time, however, many prime fishing areas are being lost due to construction of new harbors and marinas. Certain areas within the boundaries of military reservations, now closed to public access, might make alternative bait fishing sites.

   *COMMERCIAL FISHING, *SPORT FISHING, *CALIFORNIA, *BAIT FISHING, *STATISTICS, construction, marinas, geographical regions, Pacific coast region, regions, southwest U. S., fishing, industries, recreation, water sports, harbors, excavation, recreation facilities, military reservations, federal reservations, public lands, data collections

3. Abbott, Walter, "STATEMENT", in CLEAN WATER FOR THE NATION'S ESTUARIES, Transcript of Public Meeting, Biloxi, Mississippi, January 17, 1968, pp. 8-13. Federal Water Pollution Control Administration, Department of the Interior, S. E. Region, Atlanta, Georgia.

   From the standpoint of economics, the estuaries of Mississippi are best put to use as navigation channels and open sewers, recognizing that pollution growth is inevitable.

The author sees no justification for federal intervention in the management of intrastate estuarine waters. Hypereutrophication concepts are derived from "glacially formed, oligotrophic, northern lakes" which do not necessarily apply to Gulf of Mexico estuaries. He concludes, "it would appear that decrease in fresh-water influx, with associated decrease in turbidity, probably constitutes a far greater hypereutrophication menace than does inflow of domestic and industrial waste waters".

*MISSISSIPPI, *GULF OF MEXICO, *ECONOMIC JUSTIFICATION, *FEDERAL GOVERNMENT, *ADMINISTRATION, coastal plains, geographical regions, Gulf coastal plain, state governments, regions, navigation, state jurisdiction, governments, eutrophication, southeast U. S., turbidity, physical properties, gulfs, bodies of water, surface waters, waste water (pollution), liquids, liquid wastes, wastes, water types

4. Alabaster, J. S., THE EFFECT OF HEATED EFFLUENTS ON FISH, International Journal of Air and Water Pollution, Vol. 7, No. 6/7, August, 1963, pp. 541-563.

Research on thermal pollution in the rivers of Great Britain is reported. The article does not deal with estuarine waters, but conclusions may be relevant to estuarine management. Cooling water effluent from power generating stations, both with and without cooling towers, is discussed. The author states that, "This investigation was undertaken because it was believed that the direct effect of heated effluents might be important in Britain. The work has shown, however, that the chances of fishkills are rare provided the present operating conditions do not change."

*THERMAL POLLUTION, *FISHKILL, *FOREIGN COUNTRIES, water pollution, cooling water, water types, powerplants, engineering structures, industrial plants, structures, foreign research, geographical regions, regions, fish, animals, aquatic animals, aquatic life, wildlife

5. Alexander, Lewis M., NARRAGANSETT BAY: A MARINE USE PROFILE, Geography Branch, Office of Naval Research, Contract No. Nonr-396(09), NR-389-134, June, 1966.

A portion of this report deals with the commercial fish and shellfish industries of Narragansett Bay, Rhode Island. Trends in values of commercially exploitable resources are discussed. Some of the factors seen limiting the industries or causing declines in fisheries production are pollution, hurricanes, silting, and over-exploitation of the resource. Conflicts between users of the resources are discussed, and the need for more studies of management problems is mentioned.

*COMMERCIAL SHELLFISH, *COMMERCIAL FISH, *ESTUARINE FISHERIES, *RHODE ISLAND, *COMPETING USES, marine fisheries, sport fishing, fisheries, shellfish, aquatic life, invertebrates, animals, aquatic animals, wildlife, fish, water pollution, hurricanes, regions, northeast U. S. , New England, geographical regions, aquatic productivity, productivity, exploitation, silting, sedimentation, efficiencies, water utilization

6. Allen, G. W. , A BIOLOGIST'S VIEWPOINT OF MAN-MADE CHANGES IN ESTUARIES, 19th Annual Session Gulf and Caribbean Fisheries Institute (1966), Proceedings, September, 1967, pp. 69-74.

The author argues that no man-made changes in estuaries benefit estuarine production and that, in most cases, they harm it. He feels that these changes can come about in one of four ways: (1) channel and stream flow diversion, (2) industrial filling and encroachment, (3) pollution of all sorts, and (4) real estate development.

It is stated that there is a point where the benefit ratio does not equal estuarine value, and that the value of estuaries will increase in direct proportion to their destruction by so-called improvements. The author feels that point has been reached.

*AQUATIC PRODUCTIVITY, *DIRECT BENEFITS, *ECOLOGY, *ENVIRONMENTAL EFFECTS, marine fisheries, channel flow, stream flow, balance of nature, real property, industrial wastes, Mississippi River, indirect benefits, benefits, productivity, thermal pollution, fisheries, water pollution, alteration of flow, flow, wastes, surface waters, streams, running waters, rivers, interstate waters, bodies of water, encroachment, saline water intrusion

7. Allen, George W. , ESTUARINE DESTRUCTION. . . A MONUMENT TO PROGRESS, Twenty-Ninth North American Wildlife and Natural Resources Conference, Transactions, pp. 324-331.

The author presents a general discussion of "values of estuaries" and "means and methods of destruction". He argues strongly for minimizing damage to estuarine values through coordinated planning of engineering developments. He further argues that, "One of the most difficult problems that face those of us who are dependent on our marshlands and estuaries for our source of food and recreation, is the establishing of a value to use in the effective combating of such developments. . . "

The author estimates annual production value attributable to Alabama's estuarine areas as follows, without a product-by-product breakdown: "In Alabama our marine resources are centered in Mobile and Baldwin Counties, with a total estuarine area of 550,000 acres and an average depth of 12 feet. The entire production is closely connected with the Mobile Delta Area of 50,000 acres. This delta is the so-called 'mother superior' for an industrial and recreational production totaling $18, 581,000. This is a production value of $37 per acre of estuarine area, including all of Alabama's coast and estuarine marshlands annually. In one generation, generally considered as thirty years, this is a total value of $557,430,000, or around $1100 per acre."

*VALUES, *COMPETING USED, *ALABAMA, market value, property value, land appraisal, productivity, estimated costs, costs, efficiencies, water utilization, regions, southeast U. S., Gulf coastal plain, geographical regions, coastal plains, Appalachian Mountain region

8. Anderson, Arvid A., MARINE RESOURCES OF THE CORPUS CHRISTI AREA, Bureau of Business Research, The University of Texas, Research Monograph No. 21, June, 1960.

The report describes a study which developed estimates of dollar value per surface acre of the various economic uses of the bays in the Corpus Christi, Texas, area. Values estimated were for recreational used, commercial fishing, oil production, natural gas production, mudshell production, industrial and municipal uses of bay water including waste assimilation, and savings resulting from shipping goods by water rather than land. A detailed summary of value estimates is given in tabular form.

*WATER RESOURCES, *VALUE, *TEXAS, *WATER VALUES, resources, water sports, sport fishing, recreation, natural gas, mining, commercial fishing, waste water disposal, transportation, productivity, aquatic productivity, oil wells, gases, fishing, industries, waste disposal, transportation, bays, bodies of water, central U. S., Gulf coastal plain, regions, coastal plains, geographical regions, southwest U. S.

9. ANNUAL REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY, ON CIVIL WORKS ACTIVITIES, Corps of Engineers, Department of the Army, 1966.

The civil work activities of the Department of the Army, as carried out by the Corps of Engineers during fiscal year 1965, are reported. Volume 1 reviews overall program status, accomplishments, and planning to meet existing and future needs and presents summary data on water resource development by the Corps. Volume 2 contains detailed information on individual projects and activities by ports and harbors. During fiscal year 1965, expenditures were $1,198.5 million on the civil works program. Of this amount, $1,167 million was spent for rivers and harbors and flood control.

*HARBORS, *RIVERS, *WATER RESOURCES DEVELOPMENT, *FEDERAL GOVERNMENT, *PLANNING, *FEDERAL BUDGETS, *DATA COLLECTIONS, forecasting, governments, animals, navigation, beach erosion, hydroelectric power, recreation, wildlife, channel improvement, electric power, resource development, administration, flood control, control, water control, bodies of water, running streams, streams, surface waters, erosion, future planning (projected), long-term planning, project planning, short-term planning

10. 1967 ANNUAL REPORT - COOPERATIVE WATER RESOURCES RESEARCH AND TRAINING, Office of Water Resources Research, Department of the Interior, Washington, D. C., December, 1967.

This is the annual report of all research projects carried out for the OWRR during the year 1967. All projects are abstracted and listed by state, subject, and author. Two projects are concerned with estuaries; one study deals with currents in the Neuse River Estuary (North Carolina), and the other concerns flushing characteristics of lagoons and estuaries in Florida.

*PROJECTS, *CURRENTS (WATER), *NORTH CAROLINA, *FLORIDA, *LAGOONS, *RIVERS, water resources development, conservation, abstracts, documentation, bodies of water, surface waters, Appalachian Mountain region, Atlantic coastal plains, coastal plains, geographical regions, regions, southeast U. S. Gulf coastal plain, running waters, streams

11. Asano, Takashi, "DISTRIBUTION OF POLLUTIONAL LOADINGS IN SUISUN BAY", in PROCEEDINGS OF THE NATIONAL SYMPOSIUM ON ESTUARINE POLLUTION, August 23-25, 1967, pp. 441-461. Department of Civil Engineering, Stanford University, Stanford, California.

The California Department of Water Resources conducted a series of dye tracer studies during 1965 and 1966. The 1966 series was conducted jointly with the Federal Water Pollution Control Administration in the Lower Delta and Suisum Bay and in the United States Army Corps of Engineers' San Francisco Bay Model. The waste dispersive characteristics under various flow regimes and the specific effect of fresh water inflow upon the dispersion and transit of continuously discharged pollutants into the study area were investigated. Coordination of the actual waste loadings and dispersive information with proposed mathematical expressions was examined to reproduce present and future water quality conditions.

*DYE RELEASES, *DISPERSION, *WASTE DISPOSAL, *WATER QUALITY, *CALIFORNIA, mathematical studies, tracers, water types, analytical techniques, tracking techniques, flow, inflow, mixing, geographical regions, Pacific coast region, regions, southwest U. S., water pollution, fresh water

12. Auld, David V., PROTECTING THE POTOMAC AT WASHINGTON, Water Pollution Control Federation, Journal, Vol. 37, No. 3, March, 1965, pp. 275-288.

The author describes a pollution abatement program and investments in the Washington, D. C., metropolitan area. Brief capital cost estimates of alternative plans considered by the Washington Metropolitan Council of Governments are presented. The population growth in the Washington, D. C., metropolitan area is projected through the year 2000. Capital-cost outlays for storm and sanitary sewer separation projects for small segments of the metropolitan area are tabulated. These costs are reported to have averaged about $1,500 per house for detached dwellings when contracts for separation have involved groups of 30 to 75 houses.

*DISTRICT OF COLUMBIA, *SEWERS, *FLOW SEPARATION, *CAPITAL COSTS, *POLLUTION ABATEMENT, water pollution control, construction costs, conduits, conveyance structures, detached dwellings, growth rates, rates, population, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, regions, southeast U. S., abatement, northeast U. S., engineering structures, hydraulic structures, structures, costs, cities

13. Auld, David V., "WASTE DISPOSAL AND WATER SUPPLY", in PROBLEMS OF THE POTOMAC ESTUARY, January, 1964, pp. 13-18. Interstate Commission on the Potomac River Basin, Washington, D. C.

The use of the Potomac Estuary for domestic waste assimilation is examined. Reductions in biochemical oxygen demand from the installation of secondary treatment facilities in the Washington, D. C., area are discussed. Estimates of BOD loading in 1950 and in the current year are given. A system of dams for flow augmentation is advocated to offset effects of population growth in the Washington, D. C., area.

*WASTE DISPOSAL, *WATER POLLUTION CONTROL, *BIOCHEMICAL OXYGEN DEMAND, *FLOW AUGMENTATION, *DISTRICT OF COLUMBIA, water supply, supply, Virginia, Maryland, forecasting, population, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, dams, engineering structures, hydraulic structures, northeast U. S., regions, southeast U. S., oxygen demand, cities, human population, control, flow control, regulation, structures

14. Bailey, Thomas E., "ESTUARINE OXYGEN RESOURCES--PHOTOSYNTHESIS AND REAERATION", in PROCEEDINGS OF THE NATIONAL SYMPOSIUM ON ESTUARINE POLLUTION, August 23-25, 1967, pp. 310-330. Department of Civil Engineering, Stanford University, Stanford, California.

This paper presents a discussion of the primary sources of oxygen supplied to the Sacramento-San Joaquin Estuary and Suisun Bay system through photosynthesis and reaeration. Results of field surveys are presented. Changes in oxygen levels due to photosynthesis can be predicted by an empirical equation as a function of chlorophyll concentration, solar intensity, light extinction coefficient, temperature, and water depth. It was concluded, however, that reaeration and diffusion rates are too complex to be predicted reliably by empirical relationships and that direct field measurements must be made to obtain reliable data.

*REAERATION, *PHOTOSYNTHESIS, *OXYGENATION, *DIFFUSION, *CALIFORNIA, *WATER QUALITY, Pacific coast region, dissolved oxygen, chemical reactions, chlorophyll, magnesium compounds, southwest U. S., geographical regions, regions, water properties, organic compounds, pigments, plant pigments, solar radiation, radiation, temperature, water temperature

15. Bain, Richard C., Jr., "PREDICTING DIURNAL VARIATIONS IN DISSOLVED OXYGEN CAUSED BY ALGAE IN ESTUARINE WATERS, PART I", in PROCEEDINGS OF THE NATIONAL SYMPOSIUM ON ESTUARINE POLLUTION, August 23-25, 1967, pp. 250-279. Department of Civil Engineering, Stanford University, Stanford, California.

Eutrophic environments are often dominated by planktonic algal populations (phytoplankton) which can cause diurnal variations in dissolved oxygen concentrations through respiratory activity and photosynthesis. Photosynthetic oxygenation and respiratory deoxygenation rates of estuarine phytoplankton were measured at various standing crop (chlorophyll) levels. Oxygen production and consumption rates for actively growing phytoplankton populations were related to standing crop at 20 C and nonlimiting light. Variations in algal photosynthetic production rate as related to light adaption, age of cells, nutrition, temperature, and algal type are discussed.

Light-production relationships (based on oceanographic literature) were used to estimate total production of a well-mixed system. Streeter-Phelps equations were modified to include phytoplankton production and respiration rates in formulations designed to predict dissolved oxygen concentrations over a 24 hour period. An example is given, and the resulting dissolved oxygen prediction is compared with field measurements from a tidal reach of the San Joaquin River, California.

*PHYTOPLANKTON, *DISSOLVED OXYGEN, *ALGAE, *DIURNAL DISTRIBUTION, *CALIFORNIA, estimating equations, oxygenation, standing crop, microenvironment, aquatic life, environment, microorganisms, water chemistry, plants, southwest U. S., regions, Pacific coast regions, geographical regions, photosynthesis, chemical reactions, zooplankton, animals, aquatic animals, photosynthetic oxygen, gases, oxygen, oxygen demands, eutrophication

16. Barlow, J. P., C. J. Lorenzen, and R. T. Myren, EUTROPHICATION OF A TIDAL ESTUARY, Limnology and Oceanography, Vol 8, No. 2, 1963, pp. 251-262.

The growth and photosynthesis of phytoplankton in the Forge River is described. The region provides a unique environment for the growth of phytoplankton, which is shown in the photosynthesis/respiration ratio and in the rates of photosynthesis per unit of chlorophyll, or assimilation numbers that have been observed. There is distinct stratification in salinity, and the nutrients added from the river are carried seaward by circulation without significant tendency to accumulate in the deeper layer. The large amount of organic matter accumulated in the estuary is produced locally by the dense populations of plankton and algae.

*PHYTOPLANKTON, *NUTRIENTS, *EUTROPHICATION, *ALGAE, Aquatic life, aquatic plants, path of pollutants, ecology, photosynthesis, bodies of water, running waters, streams, rivers, stratification, surface waters, chemical reactions, salinity, chemical properties, water properties, plankton, plants

17. Barnes, C. A., and E. E. Collias, SOME CONSIDERATIONS OF OXYGEN UTILIZATION RATES IN PUGET SOUND, Journal of Marine Research, Vol. 17, No. 1, November 28, 1958, pp. 68-80.

The changes of local oxygen concentration with time have been determined for selected basin waters in the Puget Sound system. In the photic zone of the sea, the oxygen concentration tends to be altered by local production, diffusion and advection, exchange of oxygen across the sea surface, and biochemical utilization. The average rate of oxygen utilization was 0.016 ml per liter per day, which is higher in comparison to offshore waters. Oxygen utilization rates decreased with both decreases in DO and increases in the time that the water had been standing in the basin. Some published work on Dabob Bay has also been discussed.

*DISSOLVED OXYGEN, *WASHINGTON, *OXYGEN, geographical regions, Pacific coast region, Pacific northwest U. S., regions, biochemical oxygen demand, oxygen demand

18. Barnett, Harold J., and Chandler Morse, "NATURAL RESOURCES AND THE QUALITY OF LIFE", in READINGS IN RESOURCE MANAGEMENT AND CONSERVATION, 1965, pp. 585-594. University of Chicago Press, Chicago, Illinois.

Barnett and Chandler discuss the social problems which have arisen in relation to the use of natural resources, e.g. whether a community has pre-emptive rights to exploit a resource irrespective of the rights of other communities to the same resource. It was concluded that it would be advisable to apply a more objective methodology to the natural-resource value problems.

*RESOURCE ALLOCATION, *SOCIAL VALUES, *NATURAL RESOURCES, *COMPETITION, water resources development, values, resources, resource development

19. Barnhill, K. G., ESTIMATED COST OF DESALTING THREE FLORIDA BRACKISH WATERS, American Water Works Association, Journal, Vol. 54, No. 5, May, 1962, pp. 526-528.

The author presents estimated costs for desalting three brackish water supplies in Florida. The author draws attention to the fact that many brackish waters can be desalted at much lower cost than is possible with sea water.

*DESALINATION, *ECONOMIC FEASIBILITY, *COSTS, *BRACKISH WATER, *FLORIDA, demineralization, separation techniques, water purification, water treatment, saline water, water types, feasibility, Atlantic coastal plain, coastal plains, geographical regions, Gulf coastal plain, regions, southeast U. S.

20. Barrett, Elinore M., THE CALIFORNIA OYSTER INDUSTRY, Resources Agency of California, Department of Fish and Game, Sacramento, California, Fisheries Bulletin No. 123, 1963.

The history and future of the California oyster industry are discussed, stating that it has entered a relatively active period after being quiescent since 1910. Tables and graphs on trends in production since 1888 are provided.

*OYSTERS, *COMMERCIAL SHELLFISH, *CALIFORNIA, marketing, history, geographical regions, Pacific coast region, regions, southwest U. S., animals, aquatic animals, aquatic life, benthic fauna, benthos, invertebrates, marine animals, mollusks, shellfish

21. Baxter, Samuel S., ECONOMIC CONSIDERATIONS OF WATER POLLUTION CONTROL, Water Pollution Control Federation, Journal, Vol. 37, No. 10, October, 1965, pp. 1363-1369.

Water-pollution-control expenditures should be justified on the basis of a favorable benefit-cost ratio. The author considers the following four topics with respect to pollution-control expenditures:

1. The purposes and uses expected of receiving streams.
2. The actual benefits and improvements derived from the stream if a higher degree of treatment is used.
3. The relation between the costs and benefits from different degrees of treatment.
4. The relation of the costs and benefits of pollution control to the costs and benefits of other civic programs.

*COST-BENEFIT RATIO, *WATER POLLUTION CONTROL, *ECONOMIC JUSTIFICATION, beneficial use, control, water pollution treatment, water treatment, cost-benefit analysis

22. Bella, David A., and William E. Dobbins, "FINITE-DIFFERENCE MODELLING OF RIVER AND ESTUARY POLLUTION", in PROCEEDINGS OF THE NATIONAL SYMPOSIUM ON ESTUARINE POLLUTION, August 23-25, 1967, pp. 612-645. Department of Civil Engineering, Stanford University, Stanford, California.

One dimensional dynamic model for describing the mass balance in an estuary is described. It is shown that the resulting differential equations are too complicated for analytical solution. Numerical solution techniques are presented.

*MATHEMATICAL MODELS, *DISSOLVED OXYGEN, *WASTE ASSIMILATION, biochemical oxygen demand, mathematical studies, model studies

23. BENEFIT-COST ANALYSIS FOR WATER RESOURCE PROJECTS: A SELECTED ANNOTATED BIBLIOGRAPHY, Tennessee Valley Authority, Knoxville, Tennessee, October, 1967.

The bibliography is divided into six major subject categories:

1. Basic works	4. Pollution (quality) control
2. Flood control	5. Recreation
3. Navigation	6. Land value enhancement.

Within each subject category the abstracts are placed under the following headings:

1. Definition	4. Evaluation techniques
2. Forecasting demand	5. Decision criteria.
3. Benefit measurement and/or cost determination	

*COST-BENEFIT ANALYSIS, *WATER RESOURCES DEVELOPMENT, *BIBLIOGRAPHIES, *WATER POLLUTION CONTROL, abstracts, documentation, control, navigation, flood control, control, water control, recreation, appreciation, real property, property values, value, forecasting, evaluation

24. Berg, B., R. W. Lane, and T. C. Larson, WATER USE AND RELATED COSTS WITH COOLING TOWERS, American Water Works Association, Journal, Vol. 56, No. 3, March, 1964, pp. 311-329.

This study is primarily an economic evaluation of cooling towers for water reuse compared with once-through use. The authors state that this report presents a method whereby approximate costs for specific cooling-tower applications may be estimated and compared with the costs of non-conservative practices. The study identifies eight kinds of information needed to assess the costs of cooling-tower operations in any specific situation.

*COSTS, *COOLING TOWERS, *EVALUATION, *WATER REUSE, thermal pollution, temperature, economic feasibility, engineering structures, feasibility, assessments, cost comparisons, analysis, cost analysis, mathematical studies, water utilization, efficiencies

25. Berkeley, Norborne, Jr., THE ECONOMICS OF RECREATION, Parks and Recreation, July, 1966, pp. 549-550.

The author says that, due to automation and the shorter work week, the average American is finding himself with more free time than ever before. Our economy is geared to expanding this free time and expanding use of that free time for active recreation.

More than almost any other business field in the past twenty-five years, recreation has grown rapidly as a source of work and as an item in the budgets of most Americans. In 1964, there were approximately 35,000 full-time year-round workers in the specific field of recreation and about 100,000 part-time workers, plus millions whose jobs are indirectly dependent on recreation. And in that same year, Americans spent $24,000,000,000 on recreation, an increase of more than 500 percent since 1950.

Gallup polls have found that these leisure time activities have provided an expanding "leisure market" which by the end of 1969 will amount to an estimated 50,000,000,000.

*RECREATION DEMAND, *SOCIAL PARTICIPATION, *ECONOMIC PREDICTION, *STATISTICS, *VALUE, economic impact, recreation facilities, demand, forecasting, data collections, surveys, parks

26. Biglane, Kenneth E., "ENVIRONMENTAL REACTION TO WATER POLLUTION", in MARINE, ESTUARIAN, AND RIPARIAN POLLUTION DISASTERS AND THEIR CONSEQUENCES, Ocean Resources Subcommittee Meeting, December 12, 1967. National Security Industrial Association, Washington, D. C.

The author states that an accidental or sudden release of pollutants to the aquatic environment usually causes a more spectacular reaction by the inhabitants or users of the resource than does the continuous discharge which slowly erodes the quality of the resource.

The recovery of the resource from both sudden release and continuous waste discharges is dependent upon the type and quantity of material released. Usually, one thinks of the environment recovering much faster from the effects of a sudden and non-recurring waste discharge.

Several types of sudden release or shock-type discharges and their primary and secondary effects on the aquatic environment are discussed.

*WATER POLLUTION EFFECTS, *ENVIRONMENTAL EFFECTS, *WATER POLLUTION, *DISASTERS, social aspects

27. THE BOATING BUSINESS (1966), 1966. The Boating Industry, Chicago, Illinois.

This is a yearly trade publication which presents statistics on the pleasure boating industry. The subjects covered include: use of recreation boats; sales of boats, motors, and equipment; retail expenditures; distribution of boats and motors by state; buyer characteristics; dealer characteristics; marinas; accidents; and foreign trade.

*BOATING, *STATISTICS, recreation, marinas, data collections, water sports, recreation facilities, accidents, expenditures, foreign trade

28. BOATING FACILITIES, Vol. 1-8, 1959-1967. Outdoor Boating Club of America, Chicago, Illinois.

The Outdoor Boating Club of American compiles information and reprints on boating and related facilities in periodic publications. Eight volumes, spanning the period 1959-1967, have been published to date. The reprints contain information on the economics of building and operating marinas. Other topics include: pollution and the marina, launching-ramp construction, marina profits, marina prices, profits of dry-land marinas, the marina and the community—feasibility and benefits, marina management, boating facilities found at marinas, "From marsh to marina", "A marina is good for a city", and "Do marinas pay their way".

*RECREATION FACILITIES, *BOATING, *MARINAS, *BOAT-LAUNCHING RAMPS, *PROFIT, *PRICES, recreation, water sports, water pollution, statistics, data collections

29. Bodovitz, Joseph E., PROBLEMS OF MAINTAINING BAYS AND ESTUARIES—A PANEL, SAN FRANCISCO BAY, 32nd North American Wildlife and Natural Resources Conference, San Francisco, California, Transactions, March 13-15, 1967, pp. 120-126.

As a result of extensive diking and filling, San Francisco Bay has been reduced to 1/3 the size it was at the time of the Gold Rush. This steady filling of the Bay has prompted a detailed study and plan for the Bay waters and shoreline, scheduled for completion in January, 1969.

At present the five harmful effects of land reclamation as it exists in the San Francisco Bay are: (1) esthetics and real estate values go down, (2) recreation uses are cut by the present inaccessibility of the Bay, (3) only 75 square miles of marsh and tidelands remain to support fish and wildlife, and (4) the population will double by mid-twenty-first century, and the waters of the Bay are steadily decreasing.

*CALIFORNIA, *COASTAL ENGINEERING, *LAND RECLAMATION, land management, recreation, regions, southwest U. S., Pacific coast region, geographical regions, bays, bodies of water, management, engineering, property values, wildlife, animals, fish, aquatic animals, aquatic life

30. Bowden, K. F., THE MIXING PROCESSES IN A TIDAL ESTUARY, International Journal of Air and Water Pollution, Vol. 7, No. 4/5, June, 1963, pp. 343-356.

The author briefly reviews the literature concerned with mixing processes in a tidal estuary. A modified approach is presented to account for the significant effects of density currents upon longitudinal diffusion and the importance of stability effects on reducing vertical eddy viscosity and diffusivity.

*MIXING, *MATHEMATICAL STUDIES, *TIDAL WATERS, diffusion, density currents, currents (water), saline water-freshwater interfaces, boundaries (surfaces), interfaces, stability, viscosity, physical properties, diffusivity, hydrologic properties

31. Boyd, J. Hayden, THE QUALITY OF THE RECREATION EXPERIENCE—ITS ECONOMIC BENEFITS, unpublished paper.

Using the Tolley and Hastings equation for crowding and distance costs, one can relate intensity of use of recreation areas to marginal net benefits of use. The utility maximizing (recreation) consumer will choose that combination of crowding, travel, and admission charge which minimizes the cost of each visit and will continue to make visits as long as the marginal benefits exceed marginal costs. The recreator by this analysis bears all marginal costs.

*USE RATES, *RECREATION, *MATHEMATICAL STUDIES, *MARGINAL COSTS, *MARGINAL BENEFITS, recreation demand, motivation, value, benefits, cost-benefit analysis, demand, rates, costs, benefits

32. Boyle, Robert H., HOW TO STOP THE PILLAGE OF AMERICA, Sports Illustrated, Vol. 27, No. 24, December 11, 1967, pp. 40-53.

The author argues strongly for increased federal legislation to protect U. S. natural resources. He particularly urges Congressional legislation on thermal pollution and the protection of coastal estuaries and wetlands.

*THERMAL POLLUTION, *WETLANDS, *CONSERVATION, *LEGISLATION, natural resources, resources, water pollution

33. Braarud, T., THE EFFECT OF POLLUTION BY SEWAGE UPON THE WATERS OF THE OSLO-FJORD, Verhandlungen Internationalen Verein Limnology, Vol. 12, 1955, pp. 811-813.

This article describes the configuration of Oslo Fjord and its apparent role in the pollution effects observed. Brief consideration is given to the effects of sewage on vertebrate and invertebrate marine organisms.

*SEWAGE, *FOREIGN WATERS, *MARINE ANIMALS, *WATER POLLUTION EFFECTS, water pollution sources, domestic wastes, wastes, water types, animals, aquatic animals, aquatic life

34. Bramhall, David F., and Edwin S. Mills., A NOTE ON THE ASYMMETRY BETWEEN FEES AND PAYMENTS, Water Resources Research, Vol. 2, No. 3, 1966, pp. 615-616.

The authors review schemes for controlling industrial pollution by systems of effluent charges as opposed to systems of subsidies, with respect to short-run economic effects. They caution that the conclusions reviewed are incomplete because they deal with short-run effects only, and that there is an important asymmetry in long-run economic effects due to differences in amount of entry and exit in the long-run, depending on whether a fee or charge method is selected for use.

*WATER POLLUTION CONTROL, *INDUSTRIAL POLLUTION, *EFFLUENT, *ASSESSMENTS, control

35. Braswell, R. W., A COOLING POND PROVES CHEAPER, Electrical World, Vol. 140, No. 22, November 30, 1953, pp. 84-85.

The author evaluates the economics of two methods of cooling: cooling ponds and cooling towers. Cooling ponds were found to be cheaper in initial construction cost, lower maintenance cost, longer life, and about two percent saving in annual operating cost. Estimated costs of both methods have been worked out quite extensively. Direct use of a river for condensing with upstream recirculation was not feasible because of procurement of rights and permissions over the rich farm land.

*WATER COOLING, *COOLING TOWERS, *PONDS, *COST COMPARISONS, streams, running waters, rivers, costs, riparian rights, cooling, engineering structures, water types, recirculated water, water rights, bodies of water, lakes, standing waters, surface waters, analysis, cost analysis, mathematical studies

36. Brehmer, Morris L., "NUTRIENT ASSIMILATION IN A VIRGINIA TIDAL SYSTEM", in PROCEEDINGS OF THE NATIONAL SYMPOSIUM ON ESTUARINE POLLUTION, August 23-25, 1967, pp. 218-237. Department of Civil Engineering, Stanford University, Stanford, California.

This study was conducted to assess nutrient assimilation and phytoplankton response in the tidal James River Estuary and in the Nansemond Estuary, a tributary to the James. The assimilation of nitrogen and phosphorus was measured for a period of one year in each of the above two river systems. It was determined that the nutrient assimilation capacity of estuarine waters varies seasonally, being greatest in the winter, even though fresh water discharge levels may remain nearly constant. Data indicate that water containing dissolved solids of marine origin may be able to assimilate higher nutrient levels than fresh water without producing aquatic nuisance conditions.

*WATER PROPERTIES, *NUTRIENTS, *VIRGINIA, nitrogen compounds, phosphorus, nuisance algae, salts, tides, southeast U. S., regions, geographical regions, coastal plains, Atlantic coastal plain, inorganic compounds, metals, plankton, aquatic life, zooplankton, aquatic animals, animals, Appalachian Mountain region

37. Brehmer, Morris L., "NUTRIENTS", in PROBLEMS OF THE POTOMAC ESTUARY, January, 1964, pp. 47-50. Interstate Commission on the Potomac River Basin, Washington, D. C.

The author briefly discusses the problem of secondary pollution stemming from excessive nutrients of sewage origin in receiving waters, with specific reference to the Potomac Estuary. He presents estimates of the daily phosphorous and nitrogen enrichment of the Potomac Estuary by Washington, D. C. Research is advised in order to determine safe nutrient levels for the Potomac Estuary and to develop methods of sewage treatment to remove phosphorus and nitrogen from sewage effluents as an economic by-product. The nitrogen and phosphorous content of sewage from Washington, D. C., if valued at 10 and 8 cents respectively per pound, would have a recovered value of about $3,150,000 annually, as compared with the present annual operating cost for the sewage treatment system of about $2,100,000.

*NUTRIENTS, *EUTROPHICATION, *WATER QUALITY, *PHOSPHORUS, *NITROGEN, *COST ANALYSIS, sewage treatment, waste treatment, Maryland, Virginia, water pollution sources, water pollution effects, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, operating costs, costs, northeast U. S., regions, southeast U. S., District of Columbia, cities, inorganic compounds, metals, gases, analysis, mathematical studies

38. Brewington, M. V., CHESAPEAKE BAY, A PICTORIAL MARITIME HISTORY, 1953. Cornell Maritime Press, Cambridge, Maryland.

This history treats Chesapeake Bay as a many-factored area, and traces its growth through specific subjects such as commercial fishing, boating, sports, and others.

*HISTORY, *MARYLAND, *VIRGINIA, *BAYS, commercial fishing, fishing, industries, boating, recreation, water sports, bodies of water, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions, southeast U. S.

39. Bridges, Wayne W., "LITTERING AND OBSTRUCTIONS", in PROBLEMS OF THE POTOMAC ESTUARY, January, 1964, pp. 57-59. Interstate Commission on the Potomac River Basin, Washington, D. C.

This report defines the problem of floating debris in the Potomac Estuary. Legislation relating to the prevention and control of littering is discussed.

*MARYLAND, *VIRGINIA, *LEGISLATION, *WASTES, *FLOATING, aquatic drift, driftwood, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions, southeast U. S.

40. Brink, Robert J., OPERATING COSTS OF WASTE TREATMENT IN GENERAL MOTORS, Nineteenth Industrial Waste Conference, Proceedings, January, 1965, pp. 12-16.

The costs of waste-water treatment at the Buick Division of General Motors Corporation are reported.

*WASTE WATER TREATMENT, *INDUSTRIAL PLANTS, *OPERATING COSTS, industrial wastes, treatment facilities, waste treatment, water treatment, wastes, buildings, engineering structures, structures, costs

41. Brooks, Norman H., "DIFFUSION OF SEWAGE EFFLUENT IN AN OCEAN-CURRENT", in PROCEEDINGS OF THE FIRST INTERNATIONAL CONFERENCE ON WASTE DISPOSAL IN THE MARINE ENVIRONMENT, July 22-25, 1959, pp. 246-265. Pergamon Press, New York.

Lateral mixing of a sewage field in an ocean current has been analyzed, taking into account the increase of the eddy diffusivity as the field spreads. The exact solution of the partial differential equation balancing diffusion, advection, and mortality of coliform bacteria was derived, giving concentration as a function of the position in the horizontal plane downstream from the ideal line source. Simpler expressions were also obtained for the rate of spread of a sewage field and for concentrations along the centerline of the field downstream from the source.

The application of these results to ocean outfall problems is explained by means of an outline of general design steps for outfall design and an example taken from an outfall plan recently prepared for the City of San Diego, California.

*DIFFUSION, *WASTE DILUTION, *SEWAGE DISPOSAL, *CALIFORNIA, *OCEAN CURRENTS, outlets, design, coliforms, currents (water), municipal wastes, geographical regions, Pacific coast region, mathematical studies, model. studies, southwest U. S., regions, bacteria, microorganisms, plants, waste disposal, water pollution sources, sewage effluents, bodies of water, surface waters, mathematical models

42. Brunn, P., COASTAL RESEARCH AND ITS ECONOMIC JUSTIFICATION, Geografisk Tidsskrift, Vol. 59, 1960, pp. 33-57.

Arguments are presented for increasing the research effort in the field of coastal engineering. Many examples of engineering mistakes in jetties and other engineering structures are cited to substantiate the argument that more research is needed. With reference to Miami Beach, the author states that the unpopularity of ocean swimming at Miami Beach can be attributed to the unattractiveness and smallness of the beach area, a steep offshore bottom, dangerous currents, and too much shell material in the beach sand.

*COASTAL ENGINEERING, *JETTIES, *ECONOMIC JUSTIFICATION, *SWIMMING, coastal structures, beaches, engineering, engineering structures, coasts, recreation, water sports

43. Burbanck, W. D., "STATEMENT", in CLEAN WATER FOR THE NATION'S ESTUARIES, Proceedings of the Georgia Public Meeting, Jekyll Island, Georgia, February 20, 1968, pp. 25-30. Federal Water Pollution Control Administration, Department of the Interior, S. E. Region, Atlanta, Georgia.

The problem of pollution should be faced with two objectives:

1. To clean up areas such as Delaware Bay where pollution has become extensive and
2. To practice conservation in areas that still approximate natural conditions.

A multi-disciplinary model approach for the management of estuaries is desirable, since there are so many aspects of pollution and varied effects from it.

*WATER QUALITY CONTROL, *MODEL STUDIES, *WATER POLLUTION CONTROL, food chains, Georgia, water pollution treatment, water treatment, water pollution sources, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, regions, southeast U. S., control, soil conservation, water resources development, resource development

44. Burgess, Robert H., "THE CHESAPEAKE MARCHES ON", in THIS WAS CHESAPEAKE BAY, 1963, pp. 200-202. Cornell Maritime Press, Cambridge, Maryland.

The article describes with examples how land area ground Chesapeake Bay is shrinking annually, while the Bay itself is becoming larger.

*MARYLAND, *VIRGINIA, *BAYS, *HISTORY, *LAND SUBSIDENCE, bodies of water, land use, water utilization, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, regions, southeast U. S., northeast U. S., subsidence

45. Burgess, Robert H., THIS WAS CHESAPEAKE BAY, 1963. Cornell Maritime Press, Cambridge, Maryland.

This book is devoted to various aspects of life on Chesapeake Bay in the nineteenth century. Navigation, oyster cultivation, menhaden processing, and shipbuilding are among the topics discussed.

*HISTORY, *MARYLAND, *VIRGINIA, *BAYS, bodies of water, navigation, oysters, ships, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, regions, southeast U. S., northeast U. S., animals, aquatic animals, aquatic life, benthic fauna, benthos, commercial shellfish, invertebrates, marine animals, mollusks, shellfish, crustaceans

46. Butler, Philip A., THE PROBLEM OF PESTICIDES IN ESTUARIES, A Symposium on Estuarine Fisheries, American Fisheries Society, Special Publication No. 3, 1966, pp. 110-115.

Despite two decades of research, the extent and importance of pesticide pollution in estuaries are poorly understood. Laboratory studies of their acute and chronic toxicity indicate that pesticides may be the cause of ill-defined but significant mortality, loss of production, and, perhaps, changes in the direction of natural selection in estuarine fauna.

Preliminary investigations show the need for a continuing surveillance program to identify the seasonal and geographical distribution of pesticide pollution in estuaries.

*PESTICIDE TOXICITY, *WATER POLLUTION EFFECTS, *ESTUARINE ENVIRONMENT, *AQUATIC ANIMALS, *ENVIRONMENTAL EFFECTS, pesticides, water pollution, toxicity, toxins, mortality, morbidity, fish-kill, water pollution sources, pesticide residues, aquatic environment, environment, animals, aquatic life, pollutants, regions, seasonal, economic impact, marine animals

47. Butler, Philip A., and Paul F. Springer, PESTICIDES—A NEW FACTOR IN COASTAL ENVIRONMENTS, Twenty-Eighth North American Wildlife and Natural Resources Conference, Transactions, March, 1963, pp. 378-390.

The state of knowledge concerning the effects of pesticides on marine life is summarized.

*PESTICIDES, *COASTS, *MARINE ANIMALS, pesticide residues, pesticide toxicity, continental margin, shores, toxicity, seashores, aquatic environment, environment, aquatic life, animals, aquatic animals, water pollution effects, water pollution sources, toxins, pollutants, morbidity, mortality, water pollution

48. Cadwallader, Lewis M., STATEMENT BEFORE THE SUBCOMMITTEE ON AIR AND WATER POLLUTION, Committee on Public Works, U. S. Senate, Washington, D. C. April 17, 1968.

Cadwallader states the pros and cons of cooling towers in an estuary. There are five factors to be considered when placing cooling towers in an estuary:

1. They introduce large volumes of water vapor to the environment which can produce local fogging or icing;
2. They produce concentrated liquid wastes which are a disposal problem;
3. They are aesthetically unpleasing;
4. They present construction problems due to the corrosiveness of the salt and brackish waters on the materials used in their construction; and
5. Their salt-water vapors are potentially dangerous to nearby crops and vegetation.

*THERMAL POLLUTION, *COOLING TOWERS, *MARYLAND, *THERMAL POWERPLANTS, *POLLUTION ABATEMENT, electric powerplants, Appalachian

Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U.S., regions, engineering structures, industrial plants, powerplants, structures, water pollution, waste disposal, abatement

49. Cain, S. A., ESTUARIES: A NEGLECTED RESOURCE COMPLEX, Commercial Fisheries Review, Vol. 28, No. 10, October, 1966, pp. 27-34.

This article discusses some of the values and current problems associated with estuaries. The author states that:

1. A salt marsh in Massachusetts can yield $300/year of seafood.
2. North Atlantic coast commercial finfish landings averaged 1.6 billion pounds in a recent 10-year period; shellfish contributed about 107 million pounds, with a monetary value of $90 million.
3. In a typical year, seafood landings produced 2.2 billion pounds on the Atlantic coast; Gulf coast, 1.4 billion pounds; Pacific coast (Hawaii excluded), 1.1 billion pounds. The total worth was $362 million.
4. In 1960, three million fishermen spent more than $1/3 billion on sport fishing on the Atlantic coast.

*MONETARY BENEFITS, *COMMERCIAL FISHING, *FISH HARVEST, direct benefits, sport fishing, management, coastal marshes, salt marshes, benefits, income, return (monetary), value, commercial fish, fishing, industries, recreation, water sports, bodies of water, surface waters, marshes, wetlands, coasts, Massachusetts, geographical regions, New England, northeast U.S., regions, Atlantic Ocean, oceans, Pacific Ocean, Gulf of Mexico, gulfs

50. CALIFORNIA AND USE OF THE OCEAN, October, 1965. California State Office of Planning, University of California, Institute of Marine Resources, La Jolla, California.

This is a study of ocean resources as part of Phase II of California's Development Plan. The topics covered are: (1) urbanization; (2) weather and climate; (3) recreation; (4) wildlife preservation, conservation, research, and education; (5) waste management and pollution control; (6) water, power, and mineral resources; (7) interaction at the land-sea interface; (8) transportation and export trade; (9) engineering and technology; (10) social, legal, and economic considerations.

*CALIFORNIA, *PACIFIC OCEAN, *RESOURCE DEVELOPMENT, recreation, control, regions, wildlife conservation, transportation, conservation, technology, social aspects, legal aspects, southwest U.S., bodies of water, oceans, surface waters, urbanization, climatology, water pollution control, geographical regions, Pacific coast region

51. Cameron, W. M., and D. W. Pritchard, "ESTUARIES", in THE SEA, Vol. 2, 1963, pp. 306-324. Interscience, London, England.

The authors discuss several selected physical aspects of estuaries. Topics covered include circulation patterns, stratification, tidal flushing, estuarine dynamics, and the distribution of conservative properties such as salt concentration. The information presented is essentially descriptive.

*CIRCULATION, *STRATIFICATION, *TIDAL EFFECTS, *SALINITY, chemical properties, water properties

52. Carey, Omer L. , RECENT DEVELOPMENTS IN EVALUATING RECREATIONAL BENEFITS, Conference of the Western Economic Association, San Francisco, California, August 22, 1963.

The purpose of the paper is to stress the need for economic analyses in the planning of outdoor recreation facilities, and to enumerate some of the techniques which have been used to compute recreation benefits. These techniques include:

1. Willingness to pay.
2. Evaluating economic impact.
3. Value in use - evaluation of consumer surplus in recreation.
4. Cost of alternative facilities as a measure of benefit from public facilities.
5. Opportunity cost of a recreation site, including the "marginal method", comparing value of recreation and timber per acre of forest.

*RECREATION DEMAND, *BENEFITS, *RECREATION FACILITIES, *EXPENDITURES, *EVALUATION, recreation, economic impact, prices

53. Carver, J. A. , Jr., SOME CRITICAL PROBLEMS OF THE SHELLFISH INDUSTRY, National Shellfisheries Association, Proceedings, Vol. 56, May, 1966, pp. 9-12.

Technological inefficiency as well as outdated legislation are seen as critical problems of the shellfish industry. The author states that technological inefficiency leads to an unfavorable competitive position. Conflicts between the shellfish industry and other uses of the water resource are discussed.

*COMMERCIAL SHELLFISH, *EFFICIENCIES, *COMPETITION, *LEGISLATION, *TECHNOLOGY, *WATER POLICY, economic efficiency, fish management, competing uses, water utilization, productivity, management, fisheries, commercial fishing, methodology, industries, industrial production, water resources, resources, water management, administration, regulation, water law, animals, aquatic animals, aquatic life, invertebrates, shellfish

54. Cassidy, William F., LIMITING FACTORS IN HARBOR DEVELOPMENT, paper presented to the Tanker Conference of the American Petroleum Institute, May 10, 1966.

General Cassidy maintains that the limit to channel and harbor deepening has been reached and urges the oil companies to seek alternatives for low cost shipping other than continued construction of several-hundred-thousand-ton tankers. Joint offshore pipeline loading facilities are one suggested solution. Port use conflicts are listed.

*OIL INDUSTRY, *COMPETING USES, *HARBORS, channel improvement, navigation, industries, transportation, efficiencies, water utilization

55. Castle, Emery N., ECONOMICS OF WATER POLLUTION CONTROL, Water Pollution Control Federation, Journal, Vol. 38, No. 5, May, 1966, pp. 789-793.

This article is a brief, concise, and well-written exposition of the relationship of market economics to optimal water quality management, and of the possible techniques and institutions for resolving the problem of external diseconomies which stem from water pollution. Arguments are presented for and against (1) detailed administrative regulation, (2) maintenance of minimum standards, and (3) basinwide or regional organizations, as appropriate approaches to the external diseconomies problem. It is concluded that the latter approach is superior to the former two.

*ECONOMIC EFFICIENCY, *WATER POLLUTION CONTROL, *WATER QUALITY CONTROL, resource allocation, water quality, control, quality control, regulation, administration

56. Caulfield, Henry P., Jr., COMPREHENSIVE PLANNING IN RELATION TO THE RISE AND MANAGEMENT OF ESTUARIES, A Symposium on Estuarine Fisheries, American Fisheries Society, Special Publication No. 3, 1966, pp. 121-126.

The use and management of estuaries involve some unique physical and analytical problems not normally encountered by water planners traditionally concerned with river basins. Nevertheless, the basic analytical framework which has evolved over time in seeking solutions to river basin problems is equally applicable to estuarine problems. This framework requires an understanding of (1) fundamental objectives of planning, development, and management; (2) standards and criteria for translating these objectives into specific plans for improvement measures; and (3) processes and techniques of analysis in plan formulation to achieve stated objectives. Developing computational techniques enables persons to apply standards and criteria to an expanded array of alternative solutions and to a greater choice of selected objectives. The opportunity to achieve optimal solutions is thereby enhanced.

*MANAGEMENT, *PLANNING, *FUTURE PLANNING (PROJECTED), *LONG-TERM PLANNING, *ADMINISTRATION, economic justification, project planning, decision making, methodology, feasibility, productivity, economic efficiency

57. Chambers, G. V., and A. K. Sparks, AN ECOLOGICAL SURVEY OF THE HOUSTON SHIP CHANNEL AND ADJACENT BAYS, Institute of Marine Science, Publications, Vol. 6, 1959, pp. 213-250.

An ecological survey was initiated in the summer of 1957 with data collected at frequent regular intervals. This report includes the comparison of data on temperature, chlorinity, dissolved oxygen, and related quantities with data on fish, shrimp, and crabs caught in trawls. Data are also given on currents, bottom cores, and organic content of sediments.

Studies of bottom samples demonstrated that extensive silting has occurred in the ship channel and bays. Low dissolved oxygen, hydrogen sulfide production, and high organic content of the mud in the channel, all indicative of organic pollution, prevent the establishment of a normal bottom fauna.

A small temperature gradient was found in the ship channel, two or three degrees higher in the upper channel than in the lower part of the survey area. When dissolved oxygen (D. O.) level is sufficient, a large and diverse population of fishes exists throughout the bays in the survey area and for a considerable distance above the Humble Oil & Refining Company's outfall.

No lowering of the dissolved oxygen concentration of the ship channel attributable to Humble's effluent was found, and no effect was found to be exerted on the fish populations of the ship channel and adjacent bays by Humble's operations.

*WATER POLLUTION, *ECOLOGY, *BAYS, *FISH POPULATIONS, southwest U. S., geographical regions, coastal plains, central U. S., ecological distribution, water quality bodies of water, dissolved oxygen, organic matter, silting, sedimentation, oil wastes, Gulf coastal plain, Texas, sediments, bottom sediments, organic matter, wastes, industrial wastes, effluents, aquatic animals, animals, aquatic life, aquatic populations, population, surveys, regions

58. Chapman, Charles R., THE TEXAS BASINS PROJECT, A Symposium on Estuarine Fisheries, American Fisheries Society, Special Publication No. 3, 1966, pp. 83-92.

The proposed Texas-Basin-Project is a multiphased plan to establish 18 reservoirs to supply fresh water to a trans-Texas canal intercepting tributary discharges to all of the coastal marshes of the state. The project's area of influence, development plan, stages of construction, and operation are discussed. A general description is given of the Texas coastal fisheries. To date, the take of commercial species has been only partially exploited; and, although the trend is upwards, the overall harvest may more than double over the next three or four decades provided suitable environmental conditions in the estuary can be maintained.

Estimates and projections of population, water requirements, etc., are presented for the years 1960 and 2010. By 2010 the Texas estuaries may be called upon to provide about 17-million man-days of angling as compared to the present seven million man-days of sport-fishing for estuarine species.

*TEXAS, *COMMERCIAL FISHING, *SPORT FISHING, *PROJECT PLANNING, *HUMAN POPULATION, *WATER REQUIREMENTS, tributaries, bodies of water, canal construction, project feasibility, planning, feasibility, running water, streams, coastal marshes, fishing, industries, recreation, water sports, estuarine environment, estuarine fisheries, central U. S. , coastal plains, geographical regions, Gulf coastal plain, regions, southwest U. S. , marshes, wetlands, population, fisheries, fish harvest

59. Chapman, W. M. , "POLITICS AND THE MARINE FISHERIES", in FISHERIES OF NORTH AMERICA, First North American Fisheries Conference, Proceedings, 1965, pp. 8-16.

Reasons for the inability of the United States to compare favorably with other countries in fisheries are presented. One of these reasons is that most of our fishing regulations are at the state level and are based on such a variety of complex and sometimes involved conflicts that it is impossible to determine the effects of this legislation without extensive legal, economic, social, and resource research on the state level.

It is suggested that a Department of the Ocean be established, with a Secretary of Cabinet rank, which will coordinate within the United States all aspects of oceanography, including fisheries.

*MARINE FISHERIES, *OCEANOGRAPHY, *LEGISLATION, *POLITICAL ASPECTS, *FEDERAL GOVERNMENT, commercial fishing, competition, productivity, natural resources, fisheries, oceans, fishing, industries, legal aspects, regulation, water law, federal jurisdiction, jurisdiction, state jurisdiction, relative rights, governments, water policy, water rights, state governments, profit, foreign countries, geographical regions, regions, resources, water resources development, bodies of water, surface waters

60. Chapoton, R. B. , and J. E. Sykes, ATLANTIC COAST MIGRATION OF LARGE STRIPED BASS AS EVIDENCED BY FISHERIES AND TAGGING, American Fisheries Society, Transactions, Vol. 90, No. 1, 1961, pp. 13-20.

Migration patterns of striped bass along the east coast are described. The only known commercial fishery now being operated exclusively for striped bass on the Atlantic coast is a haul-seine fishery in North Carolina. Management of this fishery is different from most estuarine fisheries and will have to be further studied, since sport fishing exploits the fishery in three widely separated geographic areas, although spawning takes place generally in the more southern regions of the U. S. east coast.

*COMMERCIAL FISHING, *STRIPED BASS, *ATLANTIC OCEAN, *MIGRATION, sport fisheries, bodies of water, oceans, surface waters, fishing, industries, animals, aquatic animals, aquatic life, fish, marine animals, marine fish, saline water fish, sea basses, wildlife, recreation, water sports

61. CHESAPEAKE BAY STUDY TASK GROUP ON FLOOD CONTROL, NAVIGATION, EROSION, FISHERIES—MINUTES OF THE FIRST MEETING, Department of the Army, Baltimore District, Corps of Engineers, Baltimore, Maryland, April 18, 1968.

The primary discussion topics of the meeting reported were as follows:

1. Authorization and objectives of the Chesapeake Bay Study;
2. Studies that could be made with the use of a hydraulic model of the Chesapeake Bay;
3. Conversion of model data to prototype requirements;
4. Organization of task groups;
5. Outline of report to be submitted by the Corps to the Committee on Multiple Use of the Coastal Zone.

*MARYLAND, *FLOOD CONTROL, *NAVIGATION, *EROSION, *FISHERIES, federal government, governments, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S. , regions, control

62. Chin, Edward, THE BAIT SHRIMP FISHERY OF GALVESTON BAY, TEXAS, American Fisheries Society, Transactions, Vol. 89, No. 2, April, 1960, pp. 135-141.

The total production of bait shrimp in Galveston Bay, Texas, over a two-year period from June, 1957, through May, 1959, amounted to over 676,000 pounds, worth almost $779,000. The bait shrimp industry, despite its value, is not considered with the commercial fishery industry which catches shrimp for food. Whereas the fishing season for the commercial fishery is limited by state regulation, no such regulations exist for bait shrimp.

*SHRIMP, *BAIT FISHING, *TEXAS, *EVALUATION, commercial shellfish, Gulf of Mexico, legislation, animals, aquatic animals, aquatic life, crustaceans, invertebrates, shellfish, industries, industrial production, fishing, baits, bays, regions, regulation, state jurisdiction, commercial fisheries, bodies of water, gulfs, surface waters, central U. S. , coastal plains, geographical regions, Gulf coastal plain, southwest U. S.

63. Christy, Francis T. , Jr. , and Anthony Scott, THE COMMON WEALTH IN OCEAN FISHERIES, 1965. Johns Hopkins Press, Baltimore, Maryland.

The fishery resource is heterogeneous, varying widely in size, location and depth, density of population, and ease of capture. No single species is free from the possibility of depletion. All western nations have the same common-property situations in their territorial waters and the same right of access to the high seas. The size of their fishing industry depends upon the cost of labor and the cost of capital.

As in all such international industry comparisons, it is difficult to make evaluations of comparative advantage based on any measure other than value of capital goods.

The "extent of the resource" on the high seas is an unusual situation. Coastal waters are usually territorial seas and are fished only by the local industry. But the high seas fisheries are open to all. It is extremely difficult to predict how much each nation will participate in a given high seas fishery, even in static conditions. When techniques, labor costs, tastes, and incomes are changing at different rates in each country, the outcome cannot be guessed.

Ocean fisheries are undergoing a technological revolution. Devices and techniques are being developed at a rapid rate. In the absence of techniques to increase the resource base and in the face of growing demand, the stocks of fish are being subjected to heavy pressures.

Estimates of the oceans' future productivity range widely from about twice the present level of output to a billion metric tons or more. The total potential output of the oceans can be estimated at almost any level, depending upon the various assumptions about kinds of product and stages of technology.

*MARINE FISHERIES, *RESOURCE ALLOCATION, *INTERNATIONAL WATERS, *COMMERCIAL FISHING, *INTERNATIONAL LAW, economic efficiency, regulation, value, treaties, international commissions, supply, fisheries, oceans, bodies of water, surface waters, coasts, water policy, water rights, water resources, industries, legal aspects, labor supply, capital supply, technology, demand, income

64. Churchill, M. A., ANALYSIS OF A STREAM'S CAPACITY FOR ASSIMILATING POLLUTION, Sewage and Industrial Wastes, Vol. 26, July, 1954, p. 887.

The procedure presented in the paper suggests a statistical method to evaluate the effects of pollution load and stream flow on dissolved oxygen levels in the rivers. Basic data for Main River in Tennessee have been used for statistical development. A good correlation in regression lines to predict DO drop values for known BOD load condition was obtained.

*WASTE ASSIMILATIVE CAPACITY, *BIOCHEMICAL OXYGEN DEMAND, *DISSOLVED OXYGEN, *WATER POLLUTION EFFECTS, oxygen demand, southeast U. S., regions, geographical regions, rivers, bodies of water, running waters, streams, surface waters, Tennessee, Appalachian Mountain region, central U. S.

65. Ciriacy-Wantrup, S. V., WATER QUALITY, A PROBLEM FOR THE ECONOMIST, Journal of Farm Economics, Vol. 43, No. 5, December, 1961.

A general discussion of the incidence of social costs and benefits in water quality management is presented. Political and economic factors pertinent to formulation of policy objectives in water quality management are considered. Arguments are presented for a minimum quality standard for receiving waters, based on the quality required to support fish life.

*WATER QUALITY, *STANDARDS, *SOCIAL VALUES, *ADMINISTRATION, water pollution control, control, value, cost-benefit analysis

66. Clark, J., FISH AND MAN, CONFLICT IN ATLANTIC ESTUARIES, American Littoral Society, Special Publication No. 5, 1967.

This report is a discussion of the estuarine environment specifically as it relates to salt water fish, and the effect that human progress has on that environment. The conflicts are discussed between the need for conservation of our estuarine resources and the need for progress, particularly in the areas of land fill, navigation, gravel and sand mining, mosquito control and marsh impoundment, highway construction, and water control.

It is argued that even small amounts of damage to estuarine areas can lead to widespread damage to an estuarine resource.

A discussion of the economic value of fisheries is provided. It is stated that at least $75 million worth of estuarine dependent fish are landed each year along the Atlantic coast.

A review of the activities of each of the Atlantic coastal states in relation to conservation of the estuaries is given.

*ESTUARINE FISHERIES, *ESTUARINE ENVIRONMENT, *ENVIRONMENTAL EFFECTS, *PRODUCTIVITY, *FISH HARVEST, commercial fishing, commercial shellfish, sport fishing, conservation, landfills, mining, control, navigation, water control, fisheries, aquatic environment, environment, water pollution, aquatic animals, animals, aquatic life, aquatic plants, plants, Atlantic coastal plain, coastal plains, geographical regions, regions, fishing, industries, invertebrates, shellfish, value

67. Clawson, Marion, "RECREATION", in PROBLEMS OF THE POTOMAC ESTUARY, January, 1964, pp. 19-22. Interstate Commission on the Potomac River Basin, Washington, D. C.

This is a general discussion of the questions which must be answered to estimate the value of recreational benefits resulting from public investments. The material is presented in layman's terms.

*RECREATION, *MARYLAND, *VIRGINIA, *COST-BENEFIT ANALYSIS, water sports, cost allocation, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions, southeast U. S., expenditures

68. Clawson, Marion, and Jack L. Knetsch, ECONOMICS OF OUTDOOR RECREATION, 1966. Johns Hopkins Press, Baltimore, Maryland.

This book is the most comprehensive coverage available on the economics of outdoor recreation. It includes references to most of the other major papers and reports on the subject.

Demand and supply aspects of outdoor recreation are given coverage in depth. Discussion on demand includes the construction of demand curves and factors which are important in estimating demand. Alternatives to demand curves are also discussed.

Recreation supply is analyzed from the perspectives of resource use, recreation quality, and description of existing areas.

Economic considerations in outdoor recreation include: the value of land and water resources when used for recreation; economic impacts on local areas; costs and investment considerations; and pricing and paying for outdoor recreation facilities.

Future aspects include policy issues and research.

*ECONOMIC IMPACT, *RECREATION DEMAND, *RESOURCE ALLOCATION, *WATER RESOURCES, recreation, recreation facilities, social aspects, natural resources, land use, demand, supply, resources, costs, benefits, values

69. CLEAN WATER FOR THE NATION'S ESTUARIES, PROCEEDINGS OF THE PUERTO RICO PUBLIC MEETING, NATIONAL ESTUARINE POLLUTION STUDY, SANTUREE, PUERTO RICO, April 22, 1968. Federal Water Pollution Control Administration, Department of the Interior, S. E. Region, Atlanta, Georgia.

The papers presented at this meeting are chiefly concerned with industrial and sewage pollution of the bays and inlet of densely populated Puerto Rico.

A need for water pollution control within the limitations of the budget and the necessity for industrial expansion is discussed.

*PUERTO RICO, *WASTE WATER DISPOSAL, *WATER POLLUTION CONTROL, *INDUSTRIAL WASTES, *SEWAGE EFFLUENTS, water quality control, geographical regions, islands, regions, waste disposal

70. CLOSING OF THE SEA ARMS, Dienst der Zuiderzeewerken, The Hague, Netherlands, July, 1967.

There are many tangible advantages to the construction of new sea walls to close the sea arms in the Netherlands Delta area:

1. The existing coastline will be shortened, thus decreasing the force of the ocean on the land;
2. Security against floods will be increased;

3. A fresh water supply can gradually be built up in reservoirs created by the enclosures;
4. Land reclamation from presently unindated areas provides more living space for over-crowded areas;
5. Creation of new recreational areas will result;
6. Increased efficiency of transportation in the Delta area.

These advantages are offset by losses which will be suffered by the commercial fisheries in the Delta; however, it is felt that the advantages gained justify this liability.

*COASTAL ENGINEERING, *BENEFITS, *COSTS, *COMMERCIAL FISHING, *FOREIGN COUNTRIES, standing waters, shore protection, dam construction, land reclamation, drainage, reservoirs, engineering, lakes, construction, recreation, transportation, geographical regions, regions, bodies of water, impoundments, surface waters

71. Cohen, Bernard, SALINITY OF THE DELAWARE RIVER, Department of the Interior, Geological Survey, Water Resources Division, Philadelphia, Pennsylvania, 1957.

The purpose of this investigation was to obtain data on the factors affecting the salinity of the Delaware River from Philadelphia, Pennsylvania, to Reedy Island, Delaware. The techniques and results of the data analyses are presented.

The amount of salt water in the Delaware River at any location is dependent upon (1) the distance from the ocean, (2) the fresh water flow of the river, (3) the quantity of salty water moving upstream from the ocean, (4) the stage of tide, and (5) the range of tide. During the summer and early fall, the freshwater inflow is at a minimum and the mean sea level (which governs the movement of sea water into the estuary) is at a maximum—thus providing favorable conditions for movement of salt water upstream. During late October or early November the fresh-water flow increases and concurrently the sea level flow decreases, causing the salty water to recede downstream. Advance and retreat of salinity may occur at other times, depending upon the fresh-water inflow and the sea level. The severity of a salinity invasion may be estimated from sea level, river level, and fresh-water discharge data. Hurricances affect salinity as a result of wind direction and velocity, and runoff from precipitation.

*SALINE WATER INTRUSION, *SALINITY, *DELAWARE RIVER, *INFLOW, *RIVER FLOW, water properties, chemical properties, wind tides, discharge (water), bodies of water, interstate rivers, rivers, running waters, streams, surface waters, channel flow, flow, streamflow, tides

72. Colberg, M., and D. M. Windham, THE OYSTER-BASED ECONOMY OF FRANKLIN COUNTY, FLORIDA, Department of Health, Education and Welfare, Washington, D. C., 1966.

This is a study of the importance of the oyster industry, economically and socially, to the residents of Franklin County, Florida. A general description of the county and the operation of the oyster industry in the county is provided. Graphs and tables on the income of a variety of sources to the county, as well as information on per capita income, are given. Comparisons with income from the oyster industry are made. Values added to oysters at various stages of production and distribution are discussed.

*FLORIDA, *OYSTERS, animals, aquatic animals, aquatic life, benthic fauna, benthos, commercial shellfish, invertebrates, marine animals, mollusks, shellfish, employment opportunities, human resources, industries, management, fish management, industrial production, benefits, labor, economic impact, Atlantic coastal plain, coastal plain, regions, southeast U. S.

73. "COMPREHENSIVE INVESTIGATIONS AND STUDIES FOR THE DEVELOPMENT OF WATER RESOURCES", in WATER RESOURCES RESEARCH CATALOG, Office of Water Resources Research, Department of the Interior, Washington, D. C., Vol. 1, February, 1965.

This describes projects underway at the University of Colorado at Boulder. The "Water Resources Research Catalog" defines the scope of the subjects as follows: "Investigations and studies pertaining to land policies and western land development; consumption and production of electric power energy resources; laws pertaining to use and development of water, mineral, soil, forest, recreation, fish, and wildlife resources; competition for water between the natural basins as set forth in trans-mountain diversions; national needs for recreation facilities to meet national demands, use of groundwater resources; interregional cooperation for research and development of water resources; and similar problems."

H. P. Dugan is responsible for the studies described.

*WATER RESOURCES DEVELOPMENT, water management (applied), land management, management, electric power demand, demand, electric power, electric power production, legislation, wildlife, animals, fish, competition, water allocation (policy), recreation facilities, groundwater, subsurface waters, water types

74. Conomos, T. John and M. Grant Gross, "MIXING OF COLUMBIA RIVER AND OCEAN WATERS, SUMMER", in PROCEEDINGS OF THE NATIONAL SYMPOSIUM ON ESTUARINE POLLUTION, August 23-25, 1967, pp. 486-516. Department of Civil Engineering, Stanford University, Stanford, California.

This paper reviews recent work on the Columbia River estuary and the nearby Northeast Pacific Ocean. Particular attention is focused on circulation and mixing near the river mouth and on those factors controlling the supply, distribution, and utilization of plant nutrients (nitrate, inorganic phosphate, and reactive silicate) in this area during the summers of 1965 and 1966. The processes discussed here will also affect other substances discharged into the coastal ocean, making it possible, in some cases, to predict their behavior by analogy with the known behavior of these naturally occurring materials.

*WATER CIRCULATION, *COLUMBIA RIVER BASIN, *NUTRIENTS, *EUTROPHICATION, circulation, regions, river basins

75. CONSEQUENCES OF MAJOR SPILLS ON INDUSTRIAL USES OF SEAWATER, in MARINE, ESTUARIAN, AND RIPARIAN POLLUTION DISASTERS AND THEIR CONSEQUENCES, Ocean Resources Subcommittee Meeting, December 11, 1967. National Security Industrial Association, Washington, D. C.

    The article classifies water shipments into three groups: (1) petroleum and by-products, (2) natural ores, and (3) foods. Spillage of each type of cargo has a different effect on seawater; each effect is described.

    *INDUSTRIAL WATER, *WATER POLLUTION SOURCES, *SHIPS, *WATER POLLUTION EFFECTS, saline water, navigation, environmental effects, water types, transportation, oil industry, mineral industry, industries, non-consumptive use, efficiencies, water utilization, transportation

76. CONSERVATION OF THE NATURAL RESOURCES OF NEW ENGLAND, THE PASSAMAQUODDY TIDAL POWER PROJECT AND UPPER SAINT JOHN RIVER HYDROELECTRIC DEVELOPMENT, Department of the Interior, Washington, D. C., July, 1965.

    This report transmits to the President comments by various Federal and State groups and individuals concerning the report of the Passamaquoddy-Saint John River Study Committee. The latter report presents the findings of studies concerning the feasibility and desirability of the Passamaquoddy Tidal Power Project and the Upper Saint John River Hydroelectric Power Development.

    *TIDAL ENERGY, *TIDAL POWERPLANTS, *HYDROELECTRIC PLANTS, *NEW ENGLAND, *PROJECT FEASIBILITY, energy, electric powerplants, engineering structures, industrial plants, powerplants, structures, afterbays, cost-benefit analysis, geographical regions, northeast U. S., feasibility, hydroelectric power, electric power, governments

77. THE CONTRIBUTION OF THE AMERICAN MERCHANT MARINE TO THE U. S. BALANCE OF PAYMENTS, Committee of American Steamship Lines, Washington, D. C., June, 1963.

    During recent years, operations of the U. S. Marchant fleet have contributed or saved foreign exchange expenditures totaling between 3/4 and one billion dollars per year. The U. S. liner vessels presently carry less than 30 percent of the total cargo liner movement in our foreign trade. It is estimated that if their participation were increased to the 50 percent level, the U. S. Merchant Marine's favorable contribution to our balance of payments would be increased more than $250 million per year.

*SHIPS, *ECONOMIC IMPACT, *TRANSPORTATION, *BENEFITS, foreign trade, monetary benefits

78. Cooper, G. W., HURRICANE DAMAGE TO STRUCTURES, Ocean Industry, Vol. 2, No. 10, October, 1967, pp. 30-34.

These articles discuss various incidents of storm damage to offshore platforms and collision conflicts.

*OFFSHORE PLATFORMS, *HURRICANES, *DAMAGES, ocean waves, structures, engineering structures, hydraulic structures, waves (water), storms, tropical cyclones, accidents

79. Cooper, R. A., S. B. Chenoweth. and N. Marshall, CONDITION OF THE QUAHOG, MERCENARIA MERCENARIA, FROM POLLUTED AND UNPOLLUTED WATERS, Chesapeake Science, Vol. 5, No. 4, Winter, 1964, pp. 155-160.

The authors suggest that if environmental conditions which have been altered by pollution are beneficial to quahog clams, it is not evident from comparisons of the quality of meats from clams from polluted areas as opposed to clams from unpolluted areas.

*CLAMS, *WATER POLLUTION EFFECTS, *ENVIRONMENTAL EFFECTS, pollutants, water pollution, animals, aquatic animals, aquatic life, benthic fauna, benthos, commercial shellfish, invertebrates, mollusks, shellfish, water quality, estuarine environment, aquatic environment, environment

80. Cootner, P. H., and G. O. Lof, "WATER DEMAND FOR STEAM ELECTRIC GENERATION", in RESOURCES FOR THE FUTURE, 1965. Johns Hopkins Press, Baltimore, Maryland.

This publication discusses technical and economic aspects of water demand for steam electric generation. Technical information on water demand and thermal pollution is presented. Economic information is presented on water use including the economic factors involved in cooling tower technology. A regional model to calculate expected cooling water demand is developed. The report does not deal specifically with saline water use for cooling.

*ELECTRIC POWER, *WATER DEMAND, *COOLING TOWER, *THERMAL POLLUTION, economic efficiency, steam, demand, water utilization, efficiencies, heated water, engineering structures, equipment, electric power production, water pollution

81. Cory, Robert L., and John W. Nauman, TEMPERATURE AND WATER-QUALITY CONDITIONS FOR THE PERIOD JULY, 1963, TO DECEMBER, 1965, PATUXENT RIVER ESTUARY, MARYLAND, Department of the Interior, Geological Survey, Washington, D. C., Open-File Report, 1967.

Graphs and tables obtained from continuous records of surface-water temperature from five stations for the period July, 1963, through December, 1965, and of surface, salinity, dissolved oxygen, turbidity, tide-stage, wind data, and bottom temperature from a single station are presented herein.

Effects of power plant cooling water on water temperature were obvious at a station near the plant's discharge point. Surface-water density at the Patuxent River Bridge varied from 1.0033 to 1.0127 with least change during the period May to September. Salinity ranged from 3 to 16.5 parts per thousand. Average salinity in the spring of 1965 was double that of spring 1964. Turbidity was high during the winter, and peak values were obtained during prolonged periods of high wind velocities. Dissolved oxygen values ranged from 3.6 to 15.0 parts per million, and percentage saturation of oxygen from 49 to 144 percent. The extreme tidal range was 5.7 feet; mean water levels were highest in summer and lowest in winter and spring.

*MARYLAND, *WATER TEMPERATURE, *THERMAL POLLUTION, *POWER-PLANTS, *PHYSICAL PROPERTIES, *RIVERS, Atlantic coastal plain, Appalachian Mountain region, salinity, dissolved oxygen, turbidity, tides, engineering structures, industrial plants, structures, cooling water, water types, surface waters, regions, northeast U. S., geographical regions, coastal plains, temperature, water properties, water quality, winds, chemical properties, density, bodies of water, running waters, streams

82. THE COST OF CLEAN WATER, VOLUME T--SUMMARY REPORT, Federal Water Pollution Control Administration, Department of the Interior, Washington, D. C., January 10, 1968.

This report to the Congress summarizes the national requirements for, and the cost of treating, municipal, industrial, and other effluent to attain adequate water quality standards. Subject areas treated are (1) municipal pollution, (2) industrial pollution, (3) water reduction methods, (4) thermal pollution, and (5) other effluents including wastes from watercraft, oil pollution, animal feedlots, acid mine drainage, and other nonpoint sources.

*WATER QUALITY, *COSTS, *WATER POLLUTION TREATMENT, water pollution, water treatment, municipal wastes, wastes, industrial wastes, oil wastes, organic matter, ships, acid mine water, water pollution sources, acidic water, mine water, water types

83. Coulter, James B., MARINE SHIPPING INDUSTRY - EFFECTS AND IMPACTS ON THE CHESAPEAKE BAY, Governor's Conference on Chesapeake Bay, Wye Institute, Queen Anne's County, Maryland, September 12-13, 1968.

Actions to be taken by State and Federal Governments regarding water pollution and shipping channel and harbor improvements in the Chesapeake Bay area are outlined. Legislation is required to free the harbor of pullutants such as floating litter, sewage, and industrial wastes.

*LEGISLATION, *WATER POLLUTION, *CHANNEL IMPROVEMENT, *COMMERCIAL FISHING, *MARYLAND, bodies of water, water sports, recreation, Navigation, dredging, desilting, sewage effluents, separation techniques, fishing, bays, oily water, waste disposal, sewage disposal, effluents, industries, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions, navigable waters

84. Crever, F. E., THE PROSPECTS FOR DUAL-PURPOSE PLANTS, Nucleonics, Vol. 23, No. 9, September, 1965, pp. 48-50.

The author discusses several economic and technical factors related to the economic feasibility of dual-purpose desalination and power plants. Among his conclusions are the following:

1. A common misconception exists that, in combined plants, water is purified with heat that the power-generation portion would otherwise reject. In fact, water can only be obtained at the expense of power.

2. There is little question that light-water reactors can supply energy for desalting at low cost in modest-size plants--about 100 million gallons per day. But when we start considering billion-gpd capacities, we find water transportation over long distances becoming competitive.

3. The combined plant offers other advantages when both products are needed and saleable. The principal benefit derives from decreasing unit cost of nuclear steam-generating equipment with increasing size.

*DESALINATION, *ECONOMIC FEASIBILITY, *NUCLEAR POWERPLANTS, *MULTIPLE-PURPOSE PROJECTS, saline water, demineralization, separation techniques, water purification, water treatment, powerplants, engineering structures, industrial plants, structures, water types, municipal water, projects, dual purpose, feasibility, project feasibility, steam turbines, equipment, turbines, electric powerplants

85. Cronin, E. L., CHESAPEAKE BAY WATER SUPPLY NEEDS - THE BIOLOGICAL POINT OF VIEW, presented to the Eleventh Meeting, Susquehanna River Basin Study Coordinating Committee, Elmira, New York, 1965.

The author discusses the potential effects of variations in the quantity and qualities of water flowing into the Chesapeake Bay from the Susquehanna River. Discussed are such factors as changes in river flow upon salinity and, in turn, on oysters and the troublesome sea nettle. Also discussed are the potential effects on the spawning area in the Bay for striped bass, reportedly the greatest of such spawning areas in the entire world.

*SALINITY, *OYSTERS, *BASS, *WATER QUALITY, *RIVER FLOW, bodies of water, bays, spawning, shellfish, animals, aquatic animals, acuatic life, fish, freshwater fish, pan fish, water properties, chemical properties, sunfishes, wildlife, benthic fauna, benthos, commercial shellfish, invertebrates, marine animals, mollusks, water levels, channel flow, flow, streamflow

86. Cronin, Eugene, THE CONDITION OF THE CHESAPEAKE BAY, 32nd North American Wildlife and Natural Resources Conference, San Francisco, California, Transactions, March 13-15, 1967, pp. 137-150.

The author reviews the principal uses of the Chesapeake Bay and their outlook for the future:

1. Transportation - In 1964, 107,253,730 tons were handled by Baltimore and Norfolk. Baltimore alone receives approximately 5,000 ocean-going ships per year. Other uses are affected through transportation uses of the Bay, mainly through pollution by bilge pumping, overboard spillage, and channel deepening and maintenance.

2. Biotic Yield - Oyster production has been decimated by excessive exploitation and other species have been reduced by tributary dams and pollution, but changes in gear have vastly increased the catch of menhaden soft shell clams and crabs.

3. Recreation and Esthetics.

4. Waste Disposal - The Baltimore-Washington area expects its population to double from 1960 to 1985. There are three alternatives to the problem of waste disposal given in the paper.

5. The author cites other changes in the Bay which are potentially damaging to the area:

   a. Destruction and conversion of marshland;
   b. Diversion and damming of tributaries;
   c. Invasion of water plant and animal life;
   d. Land and shore erosion.

*MARYLAND, *WATER VALUES, *TRANSPORTATION, *RECREATION, *BAYS, *AQUATIC PRODUCTIVITY, *SANITARY ENGINEERING, *STATISTICS, *WASTE DISPOSAL, erosion, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U.S., regions, social values, water utilization, water resources, navigable waters, commercial fishing, fishing, bodies of water, productivity, efficiencies, engineering resources, effluents, animal ecology, plant ecology, fishing, data collections, values, ecology

87. Cronin, Eugene, "THE ROLE OF MAN IN ESTUARINE PROCESSES", in ESTUARIES, No. 83, 1967, pp. 667-686. American Association for the Advancement of Science, Washington, D. C.

The effects of civilization on estuarine processes are described. The study is divided into three major phases:

1. The physical, chemical, and biological processes which are unusually significant in the estuary and which might be modified by man.
2. How human activities have affected these processes beyond the normal range of variation present in the virgin estuary.
3. The possibilities for future management of estuarine processes for optimal achievement of human values from estuaries.

Among specific examples cited are: Tampa Bay (Florida), Lake Pontchartrain (Louisiana), Chesapeake Bay, and The Zuiderzee (Netherlands).

*MANAGEMENT, *SOCIAL ASPECTS, resource allocation, Florida, Atlantic coastal plain, coastal plains, geographical regions, Gulf coastal plain, regions, southeast U. S., Louisiana, foreign countries

88. Crutchfield, James A., CATCHING UP IN SEA-FOOD MARKETING, Fishing News International, No. 4, January-March, 1965, pp. 67-69.

Food producers in many fields are shifting toward the formation of larger firms that combine the operations of various stages of production and, thereby, ensure quality and better consumer service. The author finds, however, that the fishing industry has not taken advantage of the opportunities stemming from revolutionary changes in food marketing. He points out that the traditional conservatism of the industry and its sluggish response to changes in technology and consumer preference may lead to the loss of its market position to competing protein foods.

Most of the opportunities for cost reduction and product improvement call for integration of the catching, processing, and marketing channels leading from the fisherman to the consumer.

Linked with these kinds of integration are the mergers of firms manufacturing and distributing entirely different kinds of food products. Such mergers offer four definite benefits to the firms involved: (1) several food products marketed under one brand name produce a cumulative advertising effect; (2) processing many different lines through one plant evens out seasonal flows and makes for economy; (3) the merged firms can meet the inventory requirements of retailers and minimize the risk of stale stocks; and (4) the bigger the business, the greater its credit rating at banks and lending institutions.

*COMMERCIAL FISHING, *MARKETING, *FOODS, *ECONOMIES OF SCALE, fishing, industries, economic efficiency, fish handling facilities, facilities, industrial production

89. Crutchfield, James A., editor, THE FISHERIES: PROBLEMS IN RESOURCE MANAGEMENT, 1965. University of Washington Press, Seattle, Washington.

This book contains a series of papers and commentary on public policy issues involved in the management of fisheries resources.

The three parts of the compilation focus on different aspects of the fisheries resource. Part I provides a description of the physical setting within which fish and fishing industries exist and an analysis of the complex dynamics of fishery populations under human exploitation and regulation. Part II relates the economic motivations of a commercial fishery to these physical characteristics to provide an explanation of the need for public intervention and a set of criteria for optimal use of the resource. The problems involved in translating these principles into administratively practical problems, an essential part of the political economy of resource management, are also considered in this section. Part III examines a wide range of alternative objectives and techniques of fishery conservation from the standpoint of constitutional and international law and practice.

*COMMERCIAL FISHING, *FISH MANAGEMENT, *ECONOMIC IMPACT, *FISH POPULATION, legal aspects, natural resources, fishing, industries, fisheries, management, resource development, water resources development, fish conservation, conservation, wildlife conservation, aquatic populations, population, political aspects, regulation

90. Crutchfield, James A., Robert W. Kates, and W. R. Derrick Sewell, BENEFIT-COST ANALYSIS AND THE NATIONAL OCEANOGRAPHIC PROGRAM, Natural Resources Journal, Vol. 7, No. 3, July, 1967, pp. 361-375.

This article is an evaluation of the monograph "Economic Benefits from Oceanographic Research", published in 1964 by the National Research Council of the National Academy of Sciences.

The evaluation concludes that, "While the authors of the monograph are to be commended for a courageous attempt to develop an objective basis for appraisal of government research in a most difficult area, the results must be termed disappointing. The disappointing results may be attributed to the inevitable softness of data and data sources in any field in which the distance between basic scientific research and commercially usable end products is as great as in oceanography. In part it reflects the unavailability of a common yardstick to measure the value of commercially usable outputs and of those outputs that may ultimately prove of incalculable benefit in a material sense, but which for the moment simply represent additions of knowledge. But the study also suffers from errors in concept and fact to a degree not warranted by the present state of knowledge."

The article presents what the authors consider fallacies in the use of benefit-cost analysis. The examples presented are typical of errors that could also be made in relation to estuarine cost-benefit analysis if proper precautions were not taken.

*COST-BENEFIT ANALYSIS, *ESTIMATED BENEFITS, *ECONOMIC EFFICIENCY, cost-benefit theory, economic justification, benefits, oceanography, government finance

91. Culp, Russell L., and Ralph E. Roderick, THE LAKE TAHOE WATER RECLAMATION PLANT, Water Pollution Control Federation, Journal, Vol. 38, No. 2, February, 1966, pp. 147-155.

The authors describe the new tertiary sewage treatment plant of South Tahoe Public Utility District which produces a high quality, colorless, odorless effluent. The article represents construction and operating cost estimates for plants of 2.5, 10.0, 50.0, 100.0, and 200.0 mgd capacity, and for varying degrees of treatment. A principal conclusion is that "the total cost of providing the maximum quality tertiary treatment with this process would vary from 24¢ to 37¢/cap/month, depending on the size of the treatment plant. "This estimated cost is based upon an average estimated effluent volume of 100 gpd per capita." The authors also conclude that "tertiary treatment provides an economic advantage over desalination as a source of water, since wastewater can be renovated for only 10-15 percent of the latest realistic estimates of cost desalination".

*TERTIARY TREATMENT, *DESALINATION, *WATER REUSE, *TREATMENT FACILITIES, *COST COMPARISONS, waste water treatment, sewage treatment, waste treatment, demineralization, separation techniques, water purification, water treatment, effluents

92. Daiber, Franklin C., TIDAL MARSH - CONFLICTS AND INTERACTIONS, Estuarine Bulletin, Vol. 3, No. 1, March, 1968, pp. 4-16.

Salt marshes play an important role in the biotic economy of coastal waters. Because of conflicting uses their productivity has been reduced. Graduate students of the University of Delaware conducted an ecological study of Canary Creek marsh to attempt to answer some of the local problems in Delaware.

Topics studied were: hydrographic features, biochemical activity, plant production, quantities of detritus, zooplankton, estimation of the numbers of some of the non-planktonic invertebrates, and evaluation of the fisheries. The ecological cycle in the marsh was described.

*COMPETING USES, *SALT MARSHES, *DELAWARE, *ECOLOGY, efficiencies, marshes, wetlands, balance of nature, biochemistry, coastal marshes, hydrography, hydrologic aspects, geographical regions, regions, northeast U. S., fisheries, invertebrates, animals, detritus, plankton, aquatic life, zooplankton, aquatic animals, vegetation, Atlantic coastal plain coastal plains, water utilization

93. Davidson, Paul, F. Gerard Adams, and Joseph Seneca, "THE SOCIAL VALUE OF WATER RECREATIONAL FACILITIES RESULTING FROM AN IMPROVEMENT IN WATER QUALITY: THE DELAWARE ESTUARY", in WATER RESEARCH, 1966, pp. 175-211. Johns Hopkins Press, Baltimore, Maryland.

The authors examine the reasons for market failure in the case of water recreational facilities and conclude that the water recreational potential of a river estuary connot be left to the private sector. The benefits and costs of water recreational facilities were compared. This approach involves empirical estimation of the actual and potential useof facilities at various levels of water purity; it does not, however, solve the important question of valuation. An empirical investigation was made of the determinants of water recreational activity using consumer survey data. The results serve as the basis for an illustration of a benefit and cost analysis of water quality improvement for the Delaware River estuary.

The study was exploratory in nature, and the empirical conclusions must be considered tentative. The data point out the large volume of activity in water sports and the tendency for this activity to grow substantially over the next thirty years. The relation of certain social and economic population characteristics and their influence on recreational activity was delineated. The impact of improvement of water recreational facilities has been measured. The survey data do not record precisely the extent of activity and the factors that encourage and discourage use.

*RECREATION, *SOCIAL VALUES, *COST-BENEFIT ANALYSIS, *WATER QUALITY, *DELAWARE RIVER, recreation demand, water sports, value, demand, bodies of water, interstate rivers, rivers, running waters, streams, surface waters, water purification, water treatment

94. Davis, J. H., "INFLUENCES OF MAN UPON COAST LINES", in MAN'S ROLE IN CHANGING THE FACE OF THE EARTH, 1956. University of Chicago Press, Chicago, Illinois.

The article presents a general historical treatise on man's influence on coast lines. Presented are approximate estimates of area reclaimed from the sea in the low countries. Interesting conclusions are given concerning the lack of adapability of marsh-economy-dependent ethnic groups in the low countries and in an area of Great Britain to agricultural pursuits following drainage of marshlands. Brief consideration is given to development of coastal lands in Florida, shrinkage of the Caspian and Arab seas due to diversion of inflows, and possible role of phosphate mining in "red-tides" in the Gulf of Mexico.

*COASTAL MARSHES, *LAND RECLAMATION, *DRAINAGE EFFECTS, *DIVERSION, deposition (sediments), sedimentary structures, marshes, wetlands, drainage, sedimentation, coasts, agriculture, Florida, Atlantic coastal plain, coastal plains, geographical regions, Gulf coastal plain, regions, southeast U. S., Gulf of Mexico, bodies of water, gulfs, surface waters, oceans, management, routing, water management (applied)

95. Davis, Robert K., "PLANNING A WATER QUALITY MANAGEMENT SYSTEM: THE CASE OF THE POTOMAC ESTUARY", in WATER RESEARCH, 1966, pp. 99-121. Johns Hopkins Press, Baltimore, Maryland.

The author describes a study of the cost of alternative systems for dissolved oxygen management in the Potomac Estuary being conducted by Resources for the Future, Inc. He explains the theoretical basis and strategy of the study and presents preliminary cost estimates of achieving a specified goal for dissolved oxygen by a number of alternative methods.

*ALTERNATIVE COSTS, *MARYLAND, *VIRGINIA, *WATER QUALITY, *WATER MANAGEMENT, *DISSOLVED OXYGEN, cost-benefit analysis, costs, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions northeast U. W., regions, southeast U. W., management

96. Davis, Robert K., SOME ECONOMIC ASPECTS OF ADVANCED WASTE TREATMENT, Water Pollution Control Federation, Journal, Vol. 37, No. 12, December, 1965, pp. 1617-1628.

Research aimed at achieving least cost systems of obtaining a given water quality control objective in the Potomac Estuary is discussed. Basic economic concepts involved in determining trade offs between flow augmentation and waste treatment are presented. One principal conclusion is that higher levels of waste treatment, together with low-flow augmentation, appear to have a place in the solution of water quality management problems of the sort represented by this illustrative case. The study's view of the waste treatment process is unconventional in nature, in that it finds discontinuous operation of certain processes in the plant and possibly more than one level of intensity of operation as desirable. The reasons for this are substantial differences in capital costs and operating costs among the various processes. The first concerns the advantages of substituting operating costs for capital costs, such as might be done in a choice between chemical precipitation and additional aeration capacity for the advanced treatment.

For sanitary engineers, the study states the conclusion of interest is that in the design of treatment processes to respond to variations in pollution conditions there needs to be great weight attached to the advantages of processes which incur relatively high operating costs and relatively low capital costs. Cost data are presented to support these conclusions.

*WASTE WATER TREATMENT, *CAPITAL COSTS, *OPERATING COSTS, *WATER QUALITY CONTROL, *FLOW AUGMENTATION, costs, alternative costs, economic efficiency, methodology, quality control, control, waste treatment, regulation, water treatment, Maryland, Virginia, Appalachian Mountain region, Atlantic coastal plain, coatal plains, geographical regions, northeast U. S., regions, southeast U. W., flow control

97. DEEDS AND DATA, Water Pollution Control Federation, Journal, Vol. 36, No. 4 April, 1964, pp. 517-519.

The article presents operating and maintenance cost experience for secondary sewage treatment facilities for plants of nine municipalities, with average daily sewage volume per plant in range of 0.2 mgd to 51.6 mgd.

*SEWAGE TREATMENT, *OPERATING COSTS, maintenance costs, waste treatment, costs, sewage, municipal wastes

98. DELAWARE ESTUARY COMPREHENSIVE STUDY--PRELIMINARY REPORT AND FINDINGS, Federal Water Pollution Control Administration, Department of the Interior, Washington, D. C., June 29, 1966.

This is a preliminary report which consists of a general review of the Delaware Estuary Comprehensive Study together with the alternative water quality goals, costs, and benefits and control schemes that were considered. The study covers the length of the Delaware River from Trenton, New Jersey, to Liston Point, Delaware.

*WATER QUALITY CONTROL, *COST-BENEFIT ANALYSIS, *DELAWARE RIVER, northeast U. S., New Jersey, employment, forecasting, ecology, control, quality control, bodies of water, interstate rivers, rivers, running waters, streams, surface waters, Atlantic coastal plain, Delaware, economic prediction, coastal plains, geographical regions, regions

99. DELAWARE RIVER MODEL STUDY REPORT NO. 2 - SALINITY TESTS OF EXISTING CHANNEL, Waterways Experiment Station, U. S. Army Corps of Engimeers, Technical Memo No. 2-337, June, 1954.

Salinity intrusion in the Delaware Estuary is reported for existing (1942) channel conditions. The purposes of these studies were to determine: (1) the effects of each principal factor known or believed to affect the nature and extent of salinity intrusion in the estuary, with a view toward arriving at a proper explanation for the increase in extent of salinity intrusion that has occurred in the prototype since about 1930; and (2) the effects of the proposed Incodel Plan, involving reservoir construction and operation to regulate the fresh-water discharge of the Delaware River above Trenton, on salinities throughout the estuary and especially in the critical reach between Philadelphia and the Delaware-Pennsylvanis state line.

Descriptions of the prototype and the model and appurtenances, and a brief discussion of the hydraulic and salinity adjustment and verification are included in this report for the convenience of the reader. A sufficient number of representative plates showing the agreement attained between model and prototype hydraulic and salinity phenomena are included herein to demonstrate that the model is capable of accurately reproducing all pertinent phenomena of the prototype.

*SALINE WATER INTRUSION, *DELAWARE RIVER, *MODEL STUDIES, reservoir construction, construction, reservoir operation, discharge (water), fresh water, water types, bodies of water, interstate rivers, rivers, running waters, streams, surface waters, management, operations

100. THE DELTA PROJECT, Information Department of Ministry of Transport and Public Works, The Hague, Netherlands, March, 1967.

The Delta Project has two objectives:

1. to considerably shorten and strengthen the total length of coast and dykes washed by the sea;

2. to combat the salination of the Dutch reaches of the rivers and adjoining channels and so increase agricultural production. Land reclamation is not the purpose of the project; very little, if any, will be gained.

Working methods and new techniques are discussed.

*SHORE PROTECTION, *SALINE WATER INTRUSION, *FOREIGN COUNTRIES, *AGRICULTURAL ENGINEERING, coastal engineering, dam construction, erosion, engineering, construction, geographical regions, regions

101. Denning, Rick A., FLOW OF SOLIDS-WATER MIXTURES IN HYDRAULIC DREDGING, World Dredging and Marine Construction, Vol. 1, No. 2, Fall, 1965, pp. 28-31.

The author tries to show the relationship between rheological (flow) properties of solids-water mixtures to measures that can be taken during dredging, such as pressure drops and induced voltages. The objective is to determine the most economical pumping consistency.

*DREDGING, *RHEOLOGY, *SEDIMENT TRANSPORT, *FLOW CONTROL, viscosity, physical properties, flow, control, sedimentation, sediment discharge, mixing

102. Dial, Miller A., "STATEMENT", in CLEAN WATER FOR THE NATION'S ESTUARIES, Proceedings of the Georgia Public Meeting, Jekyll Island, Georgia, February 29, 1968, pp. 37-38. Federal Water Pollution Control Administration, Department of the Interior, S. E. Region, Atlanta, Georgia.

There are several causes of pollution which fall under the jurisdiction of the Georgia State Soil Conservation Act. Among these are: erosion of agricultural lands (contributing to silting of estuarine areas), siltation of river waters by highway rights-of-way and urban developments, and nutrient enrichment in estuaries, presumably from agricultural runoff. Under the protection of this act these kinds of pollution have been somewhat curtailed.

Other practices such as landfill and diking are also controlled by this Act.

*GEORGIA, *SEDIMENTATION, *SOIL CONSERVATION, *RUNOFF, *SOIL EROSION, rivers, cultivated lands, sediment control, erosion, conservation, silting, structures, landfills, control, legislation, regulation, water pollution control, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, regions, southeast U. S., urbanization, dikes, earthworks, embankments, engineering structures, hydraulic structures

103. Diamond, Henry L., THE POLITICS OF BEAUTY, Parks and Recreation, February, 1966, pp. 138-154.

The author notes that all factions of society are becoming concerned about the quality of the country as well as the quantity of its gross national product. Such issues as air and water pollution and urban blight are receiving widespread attention from legislature and citizenry. If the citizen wants government to represent his interests, however, he must involve himself in politics. Two things are necessary for this involvement: (1) effective organization, and (2) information on issues.

*AESTHETICS, *GOVERNMENTS, *WATER POLLUTION, *URBAN RENEWAL, air pollution

104. Different, Jack, "STATEMENT", in CLEAN WATER FOR THE NATION'S ESTUARIES, Transcript of Public Meeting, Biloxi, Mississippi, January 17, 1968, pp. 6-8. Federal Water Pollution Control Administration, Department of the Interior, S. E. Region, Atlanta, Georgia.

The Gulf Regional Planning Commission identifies four estuarine zones:
"1. Pascagoula River, with a drainage basin which contains densely developed urban areas, industrial concentrations, and extensive marsh areas;
2. Biloxi Bay, surrounded for much of its length by urban development, a planned industrial area, and a major steam-generating electric power station;
3. Bay of St. Louis, also flanked in part by urban development, only limited areas of which are adequately served by sanitary sewage collection, treatment, and disposition treatments;
4. Pearl River, a major stream with a number of urban centers and industrial installations of its middle reaches."

The regional Planning Commission is primarily concerned with the degrading effects of estuarine pollution on (1) commercial fisheries, including shellfish, (2) recreation, and (3) aesthetics, including real estate values.

*STATE GOVERNMENTS, *PLANNING, *MISSISSIPPI, *GULF OF MEXICO, *WATER POLLUTION EFFECTS, water pollution control, commercial fishing, recreation, fishing, industries, bodies of water, gulfs, surface waters, governments, coastal plains, geographical regions, regions, Gulf coastal plain, southeast U. S.

105. A DIRECTORY OF INFORMATION RESOURCES IN THE UNITED STATES: WATER, September, 1966. National Referral Center for Science and Technology, Washington, D. C.

This document lists organizations performing research or collecting data on water-related subjects. It is concerned with fresh water--the field of oceanography has been included.

*INFORMATION RETRIEVAL, *RESOURCES, *BIBLIOGRAPHIES, publications, documentation

106. Ditsworth, George R., ENVIRONMENTAL FACTORS IN COASTAL AND ESTUARINE WATERS: BIBLIOGRAPHIC SERIES - VOLUME II. COAST OF WASHINGTON, Federal Water Pollution Control Administration, Northwest Region, Pacific Northwest Water Laboratory, Corvallis, Oregon, August, 1968.

Indexed herein are references to literature pertaining to the marine waters of the State of Washington. References to these papers, most of which have been published since 1955, are indexed under one or more of the following headings: Marine Biology, Fisheries, Geology, Chemical and Physical Oceanography, Water Pollution, and Bibliographies, Literature Surveys, and Compilations.

*BIBLIOGRAPHIES, *ESTUARINE ENVIRONMENT, *WASHINGTON, aquatic environment, geographical regions, regions, Pacific coast region, Pacific northwest U. S., water pollution, aquatic life

107. Dobbins, W. E., BOD AND OXYGEN RELATIONSHIPS IN STREAMS, Journal of the Sanitary Engineering Division, Vol. 90, No. SA3, June, 1964, pp. 53-78.

Biochemical oxygen demand (BOD) removal in rivers by sedimentation and adsorption and the removal of oxygen by the benthal demand or plant respiration; plus, the addition of BOD along the stretch and the addition of oxygen by photosynthesis have important effects on the BOD and dissolved oxygen (DO) profiles. The classical equations for the BOD and DO profiles along a natural stream are modified and extended to take into account various sources of oxygen supply and demand. Methods for evaluation of mathematical constants from field measurements are presented. A theory for the mechanism of reaeration is presented, and the theoretical results are compared with measured values reported in the literature.

*BIOCHEMICAL OXYGEN DEMAND, *DISSOLVED OXYGEN, *MATHEMATICAL MODELS, *PHOTOSYNTHESIS, *STREAMS, reaeration, aeration, benthos, chemical reactions, mathematical studies, bodies of water, running waters, model studies, oxygen demand, photosynthetic oxygen, oxygen requirements, rivers, gases, oxygen, surface waters, sedimentation, adsorption

108. Dodson, R. E., and S. F. Mulford, USE OF DISTILLED SEA WATER AT SAN DIEGO, American Water Works Association, Journal, Vol. 57, September, 1965, pp. 11-6-1112.

The author describes the operations of the Point Toma, San Diego, plant for desalination. This plant was accepted by the Department of the Interior on March 5, 1962. It was dismantled in early 1964 and sent to the Guantanamo Naval Base in Cuba.

The costs to the City of San Diego are presented. These costs include water treatment and blending costs to reduce the corrosive effect of the distilled water on the distribution system.

Consumer reactions to the distilled water, as blended with regular city water, were virtually non-existent.

*SEA WATER, *DISTILLATION, *MUNICIPAL WATER, *OPERATING COSTS, *CALIFORNIA, saline water systems, desalination, saline water, demineralization, separation techniques, water purification, water treatment, water types, costs, geographical regions, Pacific coast region, regions, southwest U. S.

109. Dorfman, Robert, FORMAL MODELS IN THE DESIGN OF WATER RESOURCE SYSTEMS, Water Resources Research, Vol. 1, No. 3, 1965, pp. 329-336.

New methods for designing water resource systems are being evolved as part of a general social tendency toward expressing social problems in the formal modes that have hitherto been restricted to scientific and engineering problems. Two general models have been useful in the field of water resource development: the simulation model and the analytical model. In simulation models, temporal sequences of events are reproduced on electronic computers on a time scale in which minutes represent decades, leading to convenient estimates of the consequences of design decisions even in complicated circumstances. In analytic models, consequences are expressed as explicit mathematical functions of design variables. Simulations are awkward when a wide range of design decisions has to be evaluated; analytic models cannot be applied to practical problems without drastically simplifying them. But the two methods can be used in tandem, with analytic models delimiting the range within which simulation is required.

*MODEL STUDIES, *DESIGN, *WATER RESOURCES, mathematical models, mathematical studies, analytical techniques, simulation analysis, systems analysis, resources

110. DREDGE CLACKAMAS, Harbor News, No. 140, September, 1962, unpaged.

The Clackamas is a large pipeline dredge run by the Portland, Oregon, Port Commission to maintain the existing channel in the Columbia River. Several large industrial areas have been developed on shore deposited spoil:

1. Swan Island - airport and shipbuilding site.
2. River Gate industrial district.
3. Swan Island Industrial Park - location of more than 50 firms.

*DREDGING, *OREGON, *INDUSTRIES, *LANDFILLS, land reclamation, land development, geographical regions, Pacific coast region, Pacific northwest U. S., regions, channel improvement, sediment control, control, land development

111. THE DUTCH TURN THE TIDE, Fortune, Vol. 77, No. 3, March, 1968, pp. 132-137.

This is a short discussion, with photographs, of the Dutch overhauling their system of dams and dikes to control the movement of fresh salt water through the delta (area 1,900 square miles). Eighteen miles of dams will cost $800 million dollars. The damming will necessitate the relocation of a multimillion-dollar shellfish culture.

*DAMS, *DIKES, *COASTAL STRUCTURES, *FLOW CONTROL, land reclamation, structures, foreign projects, engineering structures, hydraulic structures, earthworks, embankments, retaining walls, walls, control, water control, commercial shellfish, animals, aquatic animals, aquatic life, invertebrates, shellfish, costs

112. Eaton, E. D., RESEARCH PROBLEMS IN WATER QUALITY AND RECREATION, Conference on Water Quality and Recreation in Ohio, Water Resources Center, The Ohio State University, Columbus, Ohio, June 15, 1966.

About $107 million were budgeted for water resources research for the 1967-68 fiscal year. There were two directions being pursued in research in water quality management:

1. To decrease the amount and potency of pollution reaching stream channels, and
2. To handle waste streams and receiving waters so as to minimize deleterious effects.

Cost-benefit evaluations of recreation programs are more difficult to maintain than an evaluation of the benefits of water quality management. There are many problems involved in such an attempted evaluation.

*WATER QUALITY CONTROL, *RECREATION, water resource development, control, quality control, resource development, water pollution, water pollution effects, cost-benefit analysis, water management (applied, management

113. ECONOMIC BENEFITS FROM OCEANOGRAPHIC RESEARCH, National Academy of Sciences--National Research Council, Washington, D. C., Report No. 1228, 1964.

This report presents estimates of the economic benefits that could result from oceanographic research and compares these benefits with the cost of doing the research. Six areas of benefits are treated; (1) fisheries, (2) marine minerals, (3) marine recreation, (4) shipping (5) sewage disposal, and (6) benefits that might result from better long-range weather forecasting. Specific estimates of these benefits are made and a cost/benefit analysis conducted in relation to each of the benefit categories. A critical analysis of this publication by Crutchfield, Kates, and Sewell appears elsewhere in this bibliography.

*COST-BENEFIT ANALYSIS, *OCEANOGRAPHY, *RECREATION, *SEWAGE DISPOSAL, *TRANSPORTATION, *MINERALOGY, *FISHERIES, *WEATHER FORECASTING, forecasting, waste disposal

114. THE ECONOMIC CONTRIBUTIONS OF THE AMERICAN MERCHANT MARINE, Committee of American Steamship Lines, Washington, D. C., June, 1963.

The contribution to the U. S. economy of the American Maritime Industry was estimated to be more than $3 billion in 1961. This contribution is measured in terms of the money that flows into the economy through the hands of employees, stockholders, government, suppliers, and others. There were more than 104,000 employees in the maritime industry in 1961, based on American steamship lines in the domestic and foreign trade, and private ship construction and repair yards.

*SHIPS, *ECONOMIC IMPACT, *BENEFITS, wages, construction, transportation, monetary benefits

115. THE ECONOMIC IMPACT OF UNITED STATES OCEAN PORTS, Maritime Administration, U. S. Department of Commerce, Washington, D. C., 1966.

This study is the first of its kind in an attempt to portray the value of the port to the economic growth of the port community and its tributary territory. There are two tables presented in this publication. One table contains the information, by each individual port, on domestic employment attributable to U. S. export, the freight traffic and direct dollar value of cargo earnings for each port area. In addition, the table shows the passenger traffic of each port, as well as the total number of vessels passing through the port. Another table presents data pertinent to ports and states relative to port development expenditures, by type of terminal, between 1946 and 1962, total Federal funds expended on port channel improvements up to 1963, the cash value of port facilities, and the proposed Federal channel improvement expenditures for 1965.

*HARBORS, *EMPLOYMENT, *TRANSPORTATION, *ECONOMIC IMPACT, ships, channel improvements, value, income, return (monetary), expenditures

116. Edinger, John E., and John Geyer, HEAT EXCHANGE IN THE ENVIRONMENT, Department of Sanitary Engineering and Water Resources, The Johns Hopkins University, Baltimore, Maryland, Project No. 49, June 1, 1965.

This report deals with the physics of heat transfer phenomena occurring in surface waters and is designed to assist engineers and scientists in carrying out temperature computations related to the heating and cooling of natural waters. In the initial chapters, known principles of meteorology, hydrodynamics, and heat transfer are used to develop general formulations for heat exchange between natural waters and the atmosphere. The formulations are then applied to situations in which temperature predictions will prove useful to the power industry.

*HEAT TRANSFER, *HEAT BALANCE, *HYDRODYNAMICS, *METEOROLOGY, thermal conductivity, powerplants, transfer, heat exchangers, equipment, cooling, fluid mechanics

117. Edinger, John Eric, and John C. Geyer, "ANALYZING STEAM ELECTRIC POWER PLANT DISCHARGES", in PROCEEDINGS OF THE NATIONAL SYMPOSIUM ON ESTAUARINE POLLUTION, August 23-25, 1967, pp. 462-485. Department of Civil Engineering, Stanford University, Stanford, California.

The temperature distribution resulting from the advection, dispersion, and cooling of water from a steam-electric-powerplant condenser is analyzed for a station located on a peninsula and discharging near the midpoint of a small estuary. A theoretical temperature distribution equation is developed and used to predict within a mile of the discharge point for various levels of operation. Temperatures are related to an equilibrium temperature toward which water temperatures are driven by meteorological conditions.

*DISCHARGE MEASUREMENT, *EQUATIONS, *HYDROELECTRIC PLANTS, *WATER COOLING, *TEMPERATURE CONTROL, thermal pollution, water pollution, cooling towers, cooling water, water types, cooling, powerplants, engineering structures, industrial plants, structures, electric powerplants, afterbays, estuarine environments, aquatic environments, environment

118. Elmore, H. L., and W. F. West, EFFECT OF WATER TEMPERATURE ON STREAM REAERATION, Journal of the Sanitary Engineering Division, Vol. 87, No. SA6, November, 1961, pp. 59-71.

A search of the literature indicated that the effect of water temperature on stream reaeration rates had not been definitively established. A series of carefully controlled experiments reported by the authors established that the temperature coefficient and reaeration coefficient remained substantially constant over a wide range of turbulence conditions and throughout the temperature range found in natural streams.

*REAERATION, *WATER TEMPERATURE, *BIBLIOGRAPHIES, *TURBULENCE, temperature

119. THE ENCLOSURE OF THE ZUIDERZEE AND THE RECLAMATION OF POLDERS IN THE YSSEL-LAKE, Zuiderzee Polders Development and Colonization Authority, Zwolle, Netherlands, 1967.

The economic significance of the reclamation works and the technical procedures of enclosure and reclamation operations are briefly described. Among procedures described are dredging, polder drainage, and soil shifting.

*LAND RECLAMATION, *SOIL MECHANICS, *FOREIGN COUNTRIES, coastal engineering, drainage, agricultural engineering, engineering, dredging, geographical regions, regions

120. THE ENCLOSURE OF THE ZUYDERZEE AND THE RECLAMATION OF THE IJSSELMEER, Dienst Der Zuiderzeewerken, The Hague, Netherlands, No. 37, November, 1967.

This bulletin describes how the enclosure of the Zuiderzee and the reclamations in the IJsselmeer were carried out.

Benefits derived from this project are listed, and the progress reports of the individual polders are given.

A set of maps illustrates operations in various stages of completion.

*LAND RECLAMATION, *BENEFITS, *FOREIGN COUNTRIES, coastal engineering, drainage, engineering, geographical regions, regions

121. ENGINEERING AND ECONOMIC FEASIBILITY STUDY FOR A COMBINATION NUCLEAR POWER-DESALTING PLANT, Bechtel Corporation, San Francisco, California, January, 1966.

This report presents results of a study to determine the feasibility of a dual purpose electric-power generation and desalting plant for the Metropolitan Water District of Southern California. The study concludes that 150 million gallons per day of desalted water can be produced by 1971 at a site cost (undelivered) of 21.9¢/thousand gallons. A critical analysis of this report has been made by Milliman. Reference to the Milliman publication also appears in this report bibliography.

*DESALINATION, *ECONOMIC FEASIBILITY, *NUCLEAR POWERPLANTS, *ELECTRIC POWER PRODUCTION, *CALIFORNIA, *WATER COSTS, forecasting, demineralization, costs, geographical regions, Pacific coast regions, regions, separation techniques, water purification, water treatment, feasibility, electric powerplants, engineering structures, industrial plants, powerplants, structures, electric power, southwest U.S.

122. Engle, J. B., THE MOLLUSCAN SHELLFISH INDUSTRY, CURRENT STATUS AND TRENDS, National Shellfish Association, Proceedings, No. 56, May, 1966, pp. 13-21.

Comparative information is provided on the internal status of commercial shellfisheries in the United States.

The oyster resource has not been adequately managed in the Chesapeake Bay, the area of greatest potential production, accounting for 50% of the total U.S. oyster production in this century. Chesapeake Bay oyster production today is only 10% of that in 1900. Production, while declining in the Chesapeake region, and even more so in the Middle Atlantic and New England regions, has increased considerably in the Gulf of Mexico and Pacific regions.

At certain regions, and during certain periods, poor management, or no management at all, has contributed to the decline. In addition, such elements as (1) pollution due to population increase and lagging sanitation improvements, (2) the "so-called improvements" of waterfronts for navigational, industrial, and domestic purposes, and the control of headwater impoundments for power, flood-control and increased water requirements, and (3) the difficulties of controlling parasites and predators have contributed to the decline of production. One other significant factor is the sales competition from more conveniently packaged and usable foods.

The increase in production in the Gulf States has been stimulated by a drop in production in the northern areas, particularly the Chesapeake Bay.

Clam production, including razor, soft shell and hard clams has increased somewhat. Of the estuarine species, the hard clam is important economically to the Middle Atlantic and New England area primarily. Many who formerly depended on oysters have converted to hard clamming as a significant adjunct to their business.

Soft-shell clam production has increased, largely due to the hydraulic dredge recently developed in Maryland. Clamming is relatively unimportant on the West Coast as far as total U. S. production.

*COMMERCIAL SHELLFISH, *CLAMS, *OYSTERS, *AQUATIC PRODUCTIVITY, *ECONOMIC IMPACT, mollusks, fish management, productivity, animals, aquatic animals, aquatic life, benthic fauna, benthos, invertebrates, shellfish, marine animals, water pollution, water control, control, predation, animal parasites, bays, bodies of water, Gulf of Mexico, gulfs, surface waters

123. English, T. Saunders, PRELIMINARY ASSESSMENT OF THE ENGLISH SOLE IN PORT GARDNER, WASHINGTON, Water Pollution Control Federation, Journal, Vol. 39, No. 8, August, 1967, pp. 1337-1350.

The biological effects of pollution in Puget Sound have been the subject of considerable dispute for many years, and more recently the subject of considerable research effort. This article presents preliminary results of research on the effects of a major sulfite paper mill submarine outfall on a single important species of finfish, the English sole. The author concludes that the multiple use of Port Gardner for receiving pulp and paper mill effluents and commercial trawling for English sole does not appear to be harmful to the fishery. The shallow area near the deep-diffuser outfall appears to be a source of young English sole recruited to an increasingly productive commercial stock. Unless some unexpected discontinuity becomes apparent, the complete life cycle of the English sole seems to be represented in Port Gardner.

*PULP WASTES, *COMMERCIAL FISH, *WATER POLLUTION EFFECTS, *WASHINGTON, water pollution sources, trawling, industrial wastes, wastes, animals, aquatic animals, aquatic life, fish, wildlife, geographical regions, Pacific northwest U. S., regions, fishing, competing uses, efficiencies, water utilization

124. EQUIPMENT FOR A DIRTY JOB, Chemical Week, Vol. 102, No. 7, February 17, 1968, pp. 69-81.

This article describes a variety of water pollution problems, as well as some equipment designed to alleviate these problems. With regard to thermal pollution, it is stated that electrical generating plants using nuclear or fossil fuels were among the first to be tagged as thermal polluters. However, a number of the process industries are also potential polluters, particularly if they are on small streams or form large industrial complexes that are highly geographically concentrated.

*THERMAL POLLUTION, *EQUIPMENT, water pollution, electric powerplants

125. ESTUARIES: IRREPLACEABLE ENVIRONMENTS, Gulf Review, Vol. 2, No. 1 September, 1967, pp. 1-2.

The article emphasizes the economic importance of estuaries and lists several current comprehensive studies on estuaries and estuarine zones.

*ECONOMIC IMPACT, *GULF OF MEXICO, *REVIEWS, water resources development, bodies of water, gulfs, surface waters

126. Farragut, Paul R., A RECONNAISSANCE STUDY OF THE CHESAPEAKE BAY, Regional Planning Council, Baltimore, Maryland, Project No. HUD:Md., p. 61.

This report discusses water resource problems in the Chesapeake Bay, with primary focus on the tidal rivers of the Maryland western shore. The topics discussed include erosion, sedimentation, tidal flooding, nutrient loading, pollution, plant and animal nuisances, and the importance of wetlands. A list of agencies responsible for planning and management of the Bay, and an extensive bibiliography are included.

*BAYS, *WATER RESOURCES, *MARYLAND, *RIVERS, *BIBLIOGRAPHIES, planning, plants, administration, resources, Appalachian Mountain region, Atlantic coastal plain, coastal plain, geographical regions, northeast U.S., regions, bodies of water, running waters, streams, surface waters, erosion, sedimentation, tidal effects, eutrophication, water pollution, animals

127. Faust, R. J., DESALINIZATION AND FUTURE WATER SUPPLY IN THE UNITED STATES, American Water Works Association, Journal, Vol. 54, No. 5, May, 1962, pp. 519-529.

Desalinization is discussed as one alternative to providing fresh water supplies in the United States. The article concludes that except for isolated cases, there is plenty of water. A distribution problem exists, but the main concern is to use present resources wisely. The reuse of treated sewage in Baltimore, Maryland, by Bethlehem Steel for industrial purposes is proposed as an example of wise water use.

*DESALINATION, *WATER SOURCES, *RECLAIMED WATER, *WATER SUPPLY, demineralization, separation techniques, water purification, water treatment, supply

128. FEASIBILITY REPORT ON THE APPLICATION OF DESALINATION TO SUPPLEMENT THE FLORIDA KEY AQUEDUCT, The Fluor Corporation, Ltd., Los Angeles, California, March, 1965.

The report discusses the feasibility of augmenting the water supply of the Florida Keys by several alternatives using desalination.

*FEASIBILITY STUDIES, *DESALINATION, *FLORIDA, *WATER SUPPLY, supply, demineralization, separation techniques, water purification, water treatment, Atlantic coastal plain, coastal plains, geographical regions, Gulf coastal plain, regions, southeast U. S.

129. FEDERAL ASSISTANCE IN OUTDOOR RECREATION, Journal of Soil and Water Conservation, Vol. 18, No. 2, March/April, 1963, pp. 57-60.

Credit, cost sharing, technical, educational, or research help in outdoor recreation in offered to states and their polical subdivisions to organizations, and to individuals by a number of federal agencies. Summaries of the various assistance programs available are given in this article.

*RECREATION, *GOVERNMENT SUPPORTS, *LAND MANAGEMENT, *COST SHARING, *CREDIT, federal government, recreation, governments, recreation demand, management

130. FEDERAL COURT DECISION JEOPARDIZES CURRENT EFFORTS TO SAFEGUARD NATION'S ESTUARIES, Conservation Foundation Letter, April 22, 1968, pp. 1-6.

The article discusses the possible implications and repercussions of a Supreme Court decision denying the right to the Corps of Engineers of considering effects on natural resources when a dredging and filling permit is to be processed. The Corps of Engineers can deny permits only for reasons of impeding navigation.

*DREDGING, *JUDICIAL DECISIONS, legal aspects, land reclamation, navigation

131. FIRST WORLD CONFERENCE ON NATIONAL PARKS, June 30-July 7, 1962. National Park Service, Department of the Interior, Washington, D. C.

Scientific, economic, and cultural values of national parks are analyzed by the delegates to the conference. The preservation of wildlife in its natural habitat is discussed. The public should be educated by the national parks to appreciate and preserve plant and animal life in its original habitat.

*NATIONAL PARKS, *WILDLIFE CONSERVATION, *ECOLOGY, natural resources, scenery, federal reservations, parks, conservation

132. FROM FISHERMAN'S PARADISE TO FARMER'S PRIDE, 1959. Netherlands Government Information Service, The Hague, Netherlands.

This is a chronicle of the enclosure and partial reclamation of the Zuiderzee, from which 550,000 acres of new land were created. SocioEconomic benefits and costs of the project are presented.

*LAND RECLAMATION, *DRAINAGE ENGINEERING, *BENEFITS, *COSTS, *FOREIGN COUNTRIES, coastal engineering shore protection, engineering, drainage, dikes, earthworks, embankments, engineering structures, hydraulic structures, structures, construction costs, farms, geographical regions, regions

133. FISHING FLEET TRIES TO CAST OFF THE PAST, Business Week, October 21, 1967, pp. 94-98.

The author summarizes discussion held at a recent Commercial Fisheries Exposition. Foreign competition in fishing fleets sales and import of fish, and obsolescence in our own industry is leading to a decline in fisheries production in the U. S. Such things as government subsidization and international control are seen as the only hopes for the future.

*COMMERCIAL FISHING, *COMPETITION, *GOVERNMENT SUPPORTS, competitive prices, fishing, fisheries, water utilization, efficiencies, prices, import, foreign trade, international commisions, marketing

134. Fitt, ACTION ON ILLEGAL DREDGING AND FILLING IN THE AREA OF HEMPSTEAD, N. Y., Estuarine Hearings, Subcommittee on Fisheries and Wildlife Conservation of the Committee on Merchant Marine and Fisheries, House of Representatives, 90th Congress, Serial No. 90-3, March 1967.

The town of Hempstead, New York, issued permits to dredge navigable waters within the town limits. In the first case, a permit was issued after work had begun; in the second case, the work was completed, after which a letter was sent to the Corps of Engineers showing extent of the dredged area.

In general, punitive action is not taken for an infraction of this nature unless the work is found to be detrimental. If corrective measures are called for, the Corps tries to have it done voluntarily. If this fails, the Department of Justice must take action.

*DREDGING, *LANDFILLS, *LOCAL GOVERNMENTS, *LEGAL ASPECTS, *NEW YORK, federal government, navigable waters, bodies of water, governments, Appalachian Mountain region, geographical regions, Great Lakes region, northeast U. S., regions

135. Fitzpatrick, W. A., and S. Russell, MASSACHUSETTS MARINE SPORT FISHERIES INVENTORY, Massachusetts Division of Fisheries and Game, December, 1961.

Figures are provided for the numbers and kinds of sport-fishing facilities along the Massachusetts coast, the catch-per-unit effort, and the total sport-fishing pressure.

*MARINE FISHERIES, *SPORT FHISHING, *MASSACHUSETTS, marine fish, creel census, geographical regions, New England, northeast U. S., regions, fisheries, animals, aquatic life, aquatic animals, fish, marine animals, saline water fish, wildlife, census, fishing, recreation, water sports, statistics, data collections

136. Flemer, David A., W. L. Dovel, H. T. Pfitzenmeyer, and D. E. Ritchie, Jr., BIOLOGICAL EFFECTS OF SPOIL DISPOSAL IN CHESAPEAKE BAY, Journal of the Sanitary Engineering Division, Vol. 94, No. SA4, August, 1968, pp. 683-706.

Field studies were made on the biota of the upper Chesapeake Bay under a design related to the shallow water disposal of channel sediments. No gross effects were observed on the phyto-zooplankton fish, eggs, and fish larvae of adult fishes. Some bottom animals were smothered over a wide area. Several benthic species survived deposition and certain species began repopulation soon after deposition.

*EUTHROPHICATION, *SEDIMENTATION, *WATER QUALITY, *WATER POLLUTION, *WASTE DISPOSAL, environment, aquatic environment, geographical regions, coastal plains, Atlantic coastal plain, wildlife, estuarine environment, ecology, growth stages, fish, plants, streamflow, water analysis, water chemistry, regions, larvae, phytoplankton, flow, channel flow, zooplankton, animals, aquatic animals, aquatic life, plankton, analysis, sediment distribution, sediment transport

137. 1966 FLORIDA TOURIST STUDY, Florida Development Commision, Tallahassee, Florida, 1966.

This study surveyed the following topics: destinations within Florida by county, number of visitors, reasons for visiting Florida, mode of transportation, distribution of tourist dollar, and tourist expenditures and tax collections.

*FLORIDA, *TOURISM, *STATISTICS, recreation, recreation demand, economic impact, demand, data collections, return (monetary), transportation, Atlantic coastal plain, coastal plains, geographical regions, Gulf coastal plain, regions, southeast U. S., expenditures

138. Frederickson, William, Jr., PUBLIC SEASHORES: THEIR ADMINISTRATION, Parks and Recreation, August, 1966, pp. 639-640.

The great popularity of beaches for recreation activities has created challenges to the park administrator.

Beachgoers are no longer satisfied to lie in the sun or wade in the surf. The city should provide recreation facilities on the beaches for more active visitors.

One city, Los Angeles, has provided three recreation areas on its public beaches: (1) children's areas, (2) athletic courts, and (3) areas for quiet recreation such as picnicking.

The response was gratifying, and the beaches are utilized as public recreation centers year round.

*BEACHES, *RECREATION FACILITIES, *BEACH EROSION, *PARKS, *PUBLIC BENEFITS, *ADMINISTRATION, sands, benefits, California, geographical regions, Pacific coast region, regions, southwest U. S.

139. Frisbie, Charles M., and Douglas E. Ritchie, Jr., SPORT FISHING SURVEY OF THE LOWER POTOMAC ESTUARY, 1959-61, Chesapeake Science, Vol. 4, No. 4, December, 1963, pp. 175-191.

A survey of the sport fishery was conducted in a 265-square-mile area of the of the lower Potomac Estuary during the summer and fall of 1959, 1960, and 1961. Fisherman interviews, postal card questionnaires, and aerial boat counts were used to determine angling pressure, rates of catch, estimated harvest, species improtance, and economic value of the sport fishery.

The 1961 estimate indicated that 101,000 angler trips produced approximately 1,200,000 fish weighing almost 642,000 pounds. Party size averaged 3.0 anglers who fished approximately 4.5 hours per trip and creeled 2.6 fish per man-our.

During the five-month survey in 1961, an estimated $594,000 was spent by Potamac Estuary anglers. The average angular spent $5.80 on each of his 29 mean yearly trips.

*SPORTS FISHING, *SURVEYS, *FISH HARVEST, *BAYS, census, fishing, recreation, water sports, Maryland, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions, Virginia, southeast U. S., statistics, data collections, creel census

140. Fussell, James R., and Richard G. Silvernail, THE IMPACT OF RECREATION ON COASTAL SOUTH CAROLINA, Business and Economic Review, Vol. 13, No. 1, October, 1966, pp. 3-7.

Coastal South Carolina is a rapidly developing recreation area. It offers beaches, a mild climate, and historical sites. The results of a survey conducted by the Bureau of Business and Economic Research indicated that:

1. The average tourist spent $81.87 over a 5.85-day vacation period on the coast;
2. Students comprised 38 percent of total visitiors;
3. Females comprised 64 percent of the student visitors.

*TOURISM, *SOUTH CAROLINA, *RECREATION, statistics, data collections, beaches, recreation demand, demand, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, regions, southeast U. S.

141. FUTURE DEVELOPMENTS OF THE SAN FRANCISCO BAY AREA, U. S. Army Corps of Engineers for the Department of Commerce, December, 1959. Office of Area Development, Business and Defense Service Administration. Department of Commerce, San Francisco, California.

This is a comprehensive survey report of the San Francisco Bay and its tributaries. The report includes projections of population, employment, land-use patterns, and estimates of reclaimable lands.

Maps are included (22) showing the historical and present land-use patterns along the original coastline and on reclaimed lands.

*LAND USE, *LAND RECLMATION, *CALIFORNIA, *FORECASTING, *HUMAN POPULATION, *HISTORY, reclamation, population, geographical regions, Pacific coast region, regions, southwest U. S., coasts

142. Gatsoff, Paul S., "ENVIRONMENTAL REQUIREMENTS OF OYSTERS IN RELATION TO POLLUTION", in BIOLOGICAL PROBLEMS IN WATER POLLUTION, Transactions of the 1959 Seminar, Report No. W60-3, 1959. Public Health Service, Department of Health, Education and Welfare.

The author describes ten major factors of oyster environment. The factors are grouped into two classes: favorable or positive and destructive or negative.

The positive factors are: charactor of bottom, temperature, salinity, water movements, and food. Only two of these factors, namely the character of bottom and food, are directly affected by pollution.

The effects of industrial wastes upon the normal food chain and bottom environment of adult and larval oysters have been described in great detail. Many examples of estuaries, bays, and harbors are described which have been greatly affected by pollution.

*FOOD CHAINS, *WATER POLLUTION EFFECTS, *ESTUARINE ENVIRONMENT, *OYSTERS, *INDUSTRIAL WASTES, temperature, commercial shellfish, invertebrates, marine animals, mollusks, shellfish, water properties, animals, aquatic animals, aquatic life, benthic fauna, benthos, bays, harbors, salinity, currents (water) temperature, beds, wastes, bodies of water, chemical properties

143. Gameson, A. L. H., POLLUTION OF LONDON'S RIVER. New Scientist (London), Vol. 22, No. 389, April, 1964, pp. 295-298.

The author presents a brief history and description of pollution conditions in the Thames estuary in the vicinity of London, including principal findings of "a 15 year study of the causes and effects of variations in pollution conditions between Teddington and the sea". The findings discussed are from a major study report entitled "Effects of Polluting Discharges on the Thames Estuary", by the Thames Survey Commission and Water Pollution Research Laboratory.

*FOREIGN COUNTRIES, *WATER POLLUTION, *HISTORY, water pollution sources, water pollution effects

144. Gameson, A. L. H., M. J. Barrett, and W. S. Preddy, PREDICTING THE CONDITION OF A POLLUTED ESTUARY, International Journal of Air and Water Pollution, Vol. 9, No. 10, October, 1965, pp. 655-664.

This paper discusses the salient features of a comprehensive study of the waste assimilation capacity of the Thames Estuary and two other estuaries in England. Field observations are compared with conditions predicted by a mathematical model. Thermal and organic pollution are considered. Extremely good correlation is noted for dissolved oxygen. Reasonably good correlation was also reported for the other parameters which were inorganic nitrogen, oxidized nitrogen, ammonical nitrogen, and temperature.

*WASTE ASSIMILATIVE CAPACITY, *THERMAL POLLUTION, *MATHEMATICAL MODELS, *FOREIGN COUNTRIES, *FORECASTING, *ORGANIC WASTES, mathematical studies, model studies, water pollution, geographical regions, regions, regions, dissolved oxygen, nitrogen compounds, water temperature, temperature, water properties, wastes

145. Gameson, A. L. H., L. Hall, and W. S. Preddy, EFFECTS OF HEATED DISCHARGES IN THE TEMPERATURE OF THE THAMES ESTUARY II, Combustion, Vol. 32, No. 7, January, 1961, p. 37.

The paper presents a mathematical model for Thames Estuary to evaluate the effect of heated discharges on the excess temperature of the estuary. Effects of tidal movement, fresh water movement, process of longitudinal mixing, and dispersion have been used in the model. Three families of curves are prepared to evaluate the temperature distribution at various sections of the estuary due to heat discharging sources at different points of the estuary. Good correlation was achieved between calculated and observed results.

*MATHEMATICAL MODELS, *HEATED WATER, *THERMAL POLLUTION, heat transfer, mixing, mathematical studies, model studies, regions, water pollution, water types, transfer, tidal effects, fresh water, dispersion, foreign countries, geographical regions.

146. The GENERAL DEVELOPMENT PLAN FOR THE ALBEMARLE, Division of Community Planning of the Department of Conservation and Development, North Carolina, November, 1964.

The Albemarle Area is a block of ten counties bordering Albemarle Sound in northeastern North Carolina. In this report the major economic activities of the area are analyzed (agriculture, forestry, fisheries, recreation). Land use and land potential are studied, including an analysis of major crop productivity in the area. Recreation and wildlife areas are pictured and characterized. Water and overland transportation are also described with development possibilities presented.

*NORTH CAROLINA, *AGRICULTURE, *RECREATION, *FISHERIES, *FORESTRY, community development, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, regions, southeast U. S., income, human resources, wildlife, animals, land use, crop production, transportation

147. GENERAL WATER QUALITY CRITERIA AND SPECIFIC WATER QUALITY STANDARDS, Water Resources Regulation 4.8, May 22, 1967. Water Resources Commision and Department of Water Resources, Annapolis, Maryland.

Pollution and types of pollution are defined in this law. Specific waters in Maryland and standards to be exacted from these waters are listed in detail. The following water-use categories are indicated: (1) shellfish harvesting, (2) public or municipal water supply, (3) water contact recreation, (4) propagation of fish, other aquatic life and wildlife, (5) agricultual water supply, (6) industrial water supply.

*STANDARDS, *WATER QUALITY, *WATER POLLUTION, *MARYLAND, *WATER LAW, *WATER SUPPLY, *SHELLFISH, control, legal aspects, Appalachian Mountain region, Atlantic coastal plain, coastal plains, supply, fish harvesting, fish, wildlife, geographical regions, regions, northeast U. S., animals, aquatic animals, aquatic life, recreation.

148. Gerard, Robert D., POTENTIAL FRESHWATER RESERVOIR IN THE NEW YORK AREA, Science, Vol. 153, No. 3138, August 19, 1966, pp. 870-871.

Estimates of the water budget of Long Island Sound suggest that it could become the largest reservoir in the United States, with freshwater surplus equal to 12 times the present needs of New York City. The engineering aspects of this undertaking are within the scope of present technology. The dam structures required to isolate this area from the sea could serve as important highway links in place of highway-bridge projects presently under study.

*NEW YORK, *RESERVOIR CONSTRUCTION, *FRESH WATER, *DAMS, Appalachian Mountain region, geographical regions, Great Lakes region, northeast U. S., water management, water types, construction management, engineering structures, hydraulic structures, structures, hydrologic budget, regions

149. Gibbs, C. V., and G. W. Isaac, METROPOLITAN SEATTLE'S DUWAMISH ESTUARY WATER QUALITY PROGRAM, Water Pollution Control Federation, Journal, Vol. 40, No. 3, March, 1968, pp. 385-394.

The Duwamish estuary study by the Municipality of Metropolitan Seattle is the most comprehensive municipally sponsored water quality study in the Pacific Northwest. The historical development of the river problem, present water quality-monitoring efforts, and results of the investigations are presented. Data collected will be used to guide the formulation of plans for future pollution-control measures.

*MONITORING, *RIVERS, *HISTORY, *WATER QUALITY CONTROL, *WASHINGTON, bodies of water, running waters, streams, surface waters, water pollution control, control, quality control, geographical regions, Pacific coast region, Pacific northwest U. S., regions, data collections, statistics

150. Gibbs, Charles V., and Ray H. Bothel, POTENTIAL OF LARGE METROPOLITAN SEWERS FOR DISPOSAL OF INDUSTRIAL WASTES, Water Pollution Control Federation, Journal, Vol. 37, No. 10, October, 1965, pp. 1417-1421.

The authors present a discussion of the economic advantages of joint treatment of municipal and industrial effluents. Also presented are construction and operating cost estimates for treatment plants of 1 mgd, 25 mgd, and 100 mgd daily capacity, and for both primary and secondary treatment.

*WASTE WATER TREATMENT, *OPERATING COSTS, *TREATMENT FACILITIES, *MUNICIPAL WASTES, sewage treatment, waste treatment, industrial wastes, economies of scale, capital costs, wastes

151. Giese, G. L., and J. W. Barr, THE HUDSON RIVER ESTUARY, A PRELIMINARY INVESTIGATION OF FLOW AND WATER-QUALITY CHARACTERISTICS, State of New York, Conservation Department, Water Resources Commission, Bulletin No. 61, 1967.

This report outlines the present level of knowledge of flow and water quality characteristics in the Hudson River estuary.

*WATER QUALITY, *FLOW, *HUDSON RIVER, *NEW YORK, hydrologic aspects, tidal waters, bodies of water, rivers, running waters, streams, surface waters, Appalachian Mountain region, geographical regions, Great Lakes region northeast U. S., regions

152. Gillespie, G. J., SAVE-THE-SALMON PROJECT ON THE ST. JOHN RIVER, Fisheries of Canada, Vol. 20, No. 4, October, 1967, pp. 9-11.

The author describes a joint project between Canada's Department of Fisheries and the New Brunswick Electric Power Commission to conserve fish which would otherwise be destroyed by a power plant. The author feels that the results of this project should have widespread consequences in regard to fish conservation practices.

*SALMON, *HYDROELECTRIC PLANTS, *MULTIPLE-PURPOSE PROJECTS, *FISH CONSERVATION, sport fish, fish hatcheries, fish management, fish migration, electric powerplants, engineering structures, industrial plants, powerplants, structures, afterbays, animals, aquatic animals, aquatic life, fish, salmonids, wildlife, conservation, wildlife conservation, projects, management

153. Glasgow, Leslie, PRESENT AND FUTURE SPORT FISHERIES RESOURCES OF THE NORTHERN GULF OF MEXICO, 11th International Game Fish Conference, International Oceanographic Institute, New Orleans, Louisiana, Nov. 18-19, 1966, pp. 15-18.

Big game fishing is now an important segment of Louisiana's economy, and interest in the sport fishing both offshore and in the estuaries is increasing. The author argues that industry and pollution along the Louisiana coast are taking their toll of the land and water areas, which are valuable breeding grounds for organisms important to the sport fishery. There are few data available on the effects of industry; however, new research will focus upon this aspect.

*SPORT FISHING, *WATER POLLUTION, *LOUISIANA, *GULF OF MEXICO, resource development, fishing, recreation, water sports, coastal plains, geographical regions, Gulf coastal plain, bodies of water, gulfs, surface waters, regions, southeast U. S.

154. Glenn, Thomas R., Jr., AN EFFECTIVE ESTUARINE POLLUTION ABATEMENT PROGRAM, A Symposium on Estauarine Fisheries, American Fisheries Society, Special Publication No. 3, 1966, pp. 116-120.

The author presents a general discussion of the creation, activities, and powers of the Interstate Sanitation Commission which was created by Compact between New York, New Jersey, and Connecticut for the abatement of existing and the control of future pollution in the waters of the New York Metropolitan Area.

*WATER POLLUTION CONTROL, *NEW YORK, *NEW JERSEY, *CONNECTICUT, *INTERSTATE COMPACTS. pollution abatement, legal aspects, legislation, administrative agencies, Appalachian Mountain region, geographical regions, Great Lakes region, northeast U. S., regions, Atlantic coastal plain, coastal plains, New England, abatement

155. Goodman, Gordon T., R. W. Edwards, and J. M. Lambert, editors, ECOLOGY AND THE INDUSTRIAL SOCIETY, 1965. John Wiley and Sons, New York.

This book is a compendium of papers delivered at The British Ecological Society Symposium in Swansea, April 13-16, 1964. Chapters most relevant to estuary problems are:

1. A survey of Water Pollution Problems
2. Ecological Aspects of the Disposal of Radioactive Wastes to the Sea
3. The Ecology of Marine Fouling
4. Pollution and Fisheries

*WATER POLLUTION, *RADIOACTIVE WASTES, *FOULING, *ECOLOGY, *FISHERIES, air pollution, sewage disposal, thermal pollution, wastes radioactive waste disposal, waste disposal, waste disposal, environmental effects, aquatic habitats, environment, habitats, aquatic life.

156. Gordon, H. Scott, THE ECONOMIC THERORY OF A COMMON-PROPERTY RESOURCE: THE FISHERY, Journal of Political Economy, Vol. 62, No. 2, 1954, pp. 124-141.

Gordon examines the economic theory of natural resource utilization in the fishing industry. He suggests that exploitation of this resource is usually unprofitable under unregulated private exploitation and proposes public (governmental) control of the industry to avoid problems of misallocation of effort.

*FISH MANAGEMENT, *FISHERIES, *REGULATION, commercial fishing, economic efficiency, natural resources, management, resources, governments, fishing, industries

157. Gove, John W., STATEMENT BEFORE THE SUBCOMMITTEE ON AIR AND WATER POLLUTION, April 17, 1968. Committee on Public Works, U. S. Senate, Washington, D. C.

The thermal effects of a large electric-generating plant on Chesapeake Bay are discussed. The conclusion is that the effluent from the plant would be more pure than natural bay water, and the discharge of warm water would not be detrimental to the ecology of the Bay. Instead, winter fisheries could be created.

*VIRGINIA, *MARYLAND, *THERMAL POWERPLANTS, *HEATED WATER, *ENVIRONMENTAL EFFECTS, southeast U. S., bays, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions, fisheries, commercial fisheries, benefits, electric powerplants, engineering structures, industrial plants, powerplants, structures, temperature, water types

158. Gottschalk, L. C., EFFECTS OF SOIL EROSION ON NAVIGATION IN UPPER CHESAPEAKE BAY, The Geographical Review, Vol. 35, No. 2, 1945, pp. 219-238.

This is an historical outlook on the damages wrought by sedimentation on the harbors and channels of Chesapeake Bay. Tobacco cultivation not only ruined topsoil in the area, but caused erosion which filled up reservoirs, channels, and harbors. Many famous ports of colonial times now lie several miles inland surrounded by swamp land, and the rivers are totally unnavigable. The author concludes that harbor and channel maintenance is most successful when supplemented by an effective soil conservation program.

*SEDIMENTATION, *MARYLAND, *BAYS, *SOIL EROSION, *NAVIGATION, erosion control, erosion, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions, control, soil conservation, conservation, channels, harbors

159. Gottschalk, L. C., SEDIMENTATION IN A GREAT HARBOR, Soil Conservation, Vol. 10, No. 1, 1947, pp. 3-12.

This article is an historical review of sedimentation trends in the Baltimore harbor area since early 1800. It is estimated that the Patapsco River and tributaries currently carry more than 16 million cubic feet of sediment into the harbor area each year..

*SEDIMENTATION, *MARYLAND, *HARBORS, *RIVERS, soil erosion, sedimentation rates, rates, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U.S., regions, erosion, history, bodies of water, running waters, streams, surface waters.

160. Gould, David H. G., "STATEMENT", in CLEAN WATER FOR THE NATION'S ESTUARIES, Proceedings of the Georgia Public Meeting, Jekyll Island, Georgia, February 29, 1968, pp. 62-69. Federal Water Pollution Control Administration, Department of the Interior, S. E. Region, Atlanta, Georgia.

Georgia has 2344 miles of tidal shoreline with a larger estuarine area than any other state. The production of food for man and animal is twice that of the best farmland and 20 times that of the open sea. The estuaries support Georgia's commercial fisheries. Here are some statistics:

1. Average wholesale value of landings and manufactured product - $25 million.
2. Number of manufacturing plants - 57.
3. Number of employees of manufacturing plants - 2000.
4. Amount of commercial landings of fish and shellfish in 1965 - 20 million pounds.
5. Dockside value of commercial landings of fish and shellfish - $4,100,000.
6. The catch by species is:
    a. Shrimp - 8,589,000 pounds.
    b. Blue crabs - 10,215,000 pounds.
    c. Oyster meals - 248,000 pounds.
    d. Roe shad - 350,000 pounds.
    e. Miscellaneous edible fish - 300,000 pounds.

Recreation is also a significant factor in the economy of the Georgia coastal area. In 1960 approximately 167,000 persons participated in sport fishing, spending an average of $80 each.

*ECONOMIC IMPACT, *COMMERCIAL FISHING, *RECREATION, *GEORGIA, *COMMERCIAL SHELLFISH, sport fishing, animals, aquatic animals, aquatic life, invertebrates, shellfish, mollusks, marine animals, benthos, benthic fauna, oysters, clams, fishing, industries, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, regions, southeast U.S., water sports, shrimp, crustaceans.

161. GOVERNMENT, INDUSTRY & SCIENCE STUDY POTENTIAL OF SEAWEEDS, Fisheries of Canada, Vol. 19, No. 11, May, 1967, pp. 3-4.

At the present time, seaweeds along Canada's Atlantic coast are worth about $1 million per year. It is stated that the resource is under-utilized and has valuable possibilities as a cash crop.

*MARINE PLANTS, *AQUATIC PRODUCTIVITY, *VALUE, marine fisheries, submerged plants, plants, aquatic plants, aquatic life, productivity, water utilization, fisheries, efficiencies, geographical regions, regions, Atlantic Ocean, bodies of water, oceans, surface waters

162. Green, Bernal L., and H. A. Wadsworth, CAMPERS, WHAT AFFECTS PARTICIPATION AND WHAT DO THEY WANT, Purdue University, Agricultural Extension Station, Lafayette, Indiana, Research Bulletin No. 233, December, 1966, pp. 3-23.

This study concerns the attractions and needs of camping as a recreation activity. The variables that tend to have a significant effect on participation in camping are: (1) occupation, (2) age, (3) vacation, (4) education, and (5) type of camping outfit. Generally speaking, persons classified as managers and laborers do the most camping, participation decreases with age, participation increases with days of paid vacation and education, and campers with the more expensive types of camping outfits do the most camping.

Consideration of price elasticity of demand is especially justified since the preferred product mix includes several recreational products rather than only one. The produce mix (other recreational activities) preferred by campers on camping trips includes swimming, hiking, fishing, playground facilities, and boating. These five activities received 508 of 590 first-choice votes. The water-based activities (swimming, fishing, and boating) received 346, or 59 percent, of the 590 first-choice votes. Each of the remaining names of recreational activities and facilities received few votes. These data indicate that the preferred product mix is water-based.

*CAMPING, *STATISTICS, *RECREATION DEMAND, recreation facilities, use rates, land management, recreation, swimming, water sports, data collections, fishing, boating, demand

163. GULF OF MEXICO IS STILL BOOMING, Offshore, Vol. 27, No. 7, June 20, 1967, pp. 60-69.

The offshore oil potential of the Gulf of Mexico is examined, and drilling forecasts and completions are tabulated. Louisiana reserves are compared to total United States reserves, and sizes of production wells are discussed.

*OIL INDUSTRY, *OIL RESERVOIRS, *OIL WELLS, *GULF OF MEXICO, *DATA COLLECTIONS, resources, drilling, natural gas, oil, wells, drill holes, Louisiana, Texas, Florida, industries, exploitation, gases, organic compounds, natural resources, coastal plains, geographical regions, Gulf coastal plain, regions, southeast U. S., gulfs, bodies of water, surface waters, oil field

164. Gunter, Gordon, THE GULF OF MEXICO MENHADEN FISHERY IN RELATION TO THE SPORTS FISHERY, Gulf and Caribbean Fisheries Institute, Proceedings, Vol. 16, 1964.

The author argues that the menhaden fisheries do not conflict with estuarine sport fisheries or other commercial fisheries because the fishing gear does not select for the other species of fish, nor does it destroy the estuarine habitat, as alleged.

*SPORT FISHING, *FISHING GEAR, *GULF OF MEXICO, *COMMERCIAL FISHING, *COMPETING USES, commercial fish, bodies of water, surface waters, gulfs, fishing, recreation, water sports, equipment

165. Gunter, Gordon, HOW DOES SILTATION AFFECT FISH PRODUCTION, National Fisherman, Vol. 38, No. 3, April, 1957, pp. 18-19.

The author, Director of the Gulf Coast Research Laboratory, presents a general discussion of the effects of siltation on fish production. He states that "it is my impression that biologists and conservationists are prone to assume that silting is all bad, terrible, and destructive. This arises from the fact that we are naturally impressed by the bad side of a situation, especially if it is of catastrophic nature, and if we are ignorant of the beneficial aspects of the case." He further states that he is not impressed by the objections to sedimentation caused by mudshell dredges. "Mudshell dredges might actually do some good in that they stir up the bottom and bring up the nutrient salts such as phosphates which are buried in the sediments when they are deposited. In fact, such operations have roughly the same effect as plowing of the land." He concludes that "we know very little about sedimentation or siltation and related matters".

*SEDIMENTATION, *SILTING, *FISH, sediments, dredging, fish harvest, effects, animals, aquatic animals, aquatic life, wildlife, phosphates, phosphorous compounds, nutrients

166. Gunter, Gordon, and Jack McKee, ON OYSTERS AND SULFITE WASTE LIQUOR, Pollution Control Commission of the State of Washington, February, 1960.

Information dealing with the effects of sulfite wastes from pulp mills on the oyster industry of Washington is reviewed. Recommendations are made to the Pollution Control Commission pertinent to the adaption of water quality standards for water on or near oyster beds.

*OYSTERS, *WATER POLLUTION, *INDUSTRIAL WASTES, *SULFITE LIQUORS, *PULP WASTES, *WASHINGTON, pollution abatement, ecology, water pollution control, wastes, sulfur compounds, geographical regions, Pacific coast region, Pacific northwest U. S., animals, aquatic animals, aquatic life, benthic fauna, benthos, commercial shellfish, shellfish, invertebrates, marine animals, mollusks, regions, water quality, standards

167. Gurnham, C. Fred, editor, INDUSTRIAL WASTEWATER CONTROL, 1965. Academic Press, New York.

This is a basic text and reference work on the subject of industrial waste water treatment. It contains chapters on the industrial waste water control in the following industries:

1. Meat
2. Fish and fish products
3. Poultry and eggs
4. Dairy products
5. Canned foods
6. Starch and starch products
7. Sugar
8. Fermentation products
9. Coal mining
10. Metal mining
11. Industrial mineral mining
12. Coke and gas
13. Iron and Steel
14. Nonferrous metals
15. Petroleum
16. Inorganic chemicals
17. Organic chemicals
18. Metal finishing products
19. Pulp and paper
20. Textiles
21. Leather
22. Power
23. Atomic energy
24. Transportation

*INDUSTRIAL WASTES, *INDUSTRIAL PLANTS, *WASTE WATER TREATMENT, *WATER POLLUTION CONTROL, water pollution sources, buildings, engineering structures, structures, waste treatment, water treatment, industries

168. Halladay, William B., ECONOMIC ASPECTS OF THE DELAWARE RIVER ESTUARY PROGRAM, presented to the American Association of Cost Engineers, 1967 Annual Convention, Cleveland, Ohio, July 10-12, 1967.

The author brings out the various cost-benefit relations involved in the Delaware River Estuary. He mentions the problem of emotion and politics often overshadowing need and economic fact in water quality legislation.

*COST-BENEFIT ANALYSIS, *DELAWARE RIVER BASIN COMMISSION, *DELAWARE RIVER, water quality, legislation, management, interstate commissions, river basin commissions, bodies of water, interstate rivers, rivers, running waters, streams, surface waters, political aspects, economics

169. Hammond, R. J., BENEFIT-COST ANALYSIS AND WATER POLLUTION CONTROL, Food Research Institute, Stanford University, Stanford, California, Miscellaneous Publication 13, 1960.

This report presents the author's opinions regarding benefit-cost analysis as applied to water pollution control. The report delves into the history of benefit-cost analysis and presents a general discussion on its use for the analysis of water resource investment. The author is, in general, pessimistic about the value of benefit-cost techniques in relation to water quality control. An excellent bibliography is included in the report.

*COST-BENEFIT ANALYSIS, *WATER POLLUTION CONTROL, *BIBLIOGRAPHIES, direct benefits, indirect benefits, economics, tangible benefits, intangible benefits, waste treatment, pollution abatement, benefits, control, abatement, water quality control, quality control

170. Harleman, Donald R. F., Chok-hung Lee, and Lawrence C. Hall, "NUMERICAL SOLUTION OF THE UNSTEADY, ESTUARY DISPERSION EQUATION", in PROCEEDINGS OF THE NATIONAL SYMPOSIUM ON ESTUARINE POLLUTION, August 23-25, 1967, pp. 586-611. Department of Civil Engineering, Stanford University, Stanford, California.

The purpose of this paper is to develop a mathematical model which accurately describes the advective (horizontal) motion (including the tidal and fresh water flow) and the longitudinal dispersion term for a variable estuary of arbitrary geometry. This extends previous studies which have assumed that the advective term is due solely to the fresh water discharge and which have ignored advection due to the tidal motion in an estuary. The model developed requires numerical solution procedures.

*MATHEMATICAL MODELS, *TIDAL EFFECTS, *FRESH WATER, *DISPERSION, mathematical studies, model studies, water types, flow profiles

171. Hartzog, George B., Jr., CONSERVATION AND MANAGEMENT OF SEASHORE AND UNDERWATER AREAS FOR PUBLIC ENJOYMENT, Latin American Conference on Conservation of Renewable Natural Resources, International Union for the Conservation of Nature and Natural Resources, San Carlos de Bariloche, Rio Negro, Argentina, No. 336I-368, March 27-April 2, 1968.

The acreage of seacoast available for public enjoyment is rapidly decreasing, due to three major factors:

1. Real estate speculation and private ownership of ocean front property;
2. Water pollution;
3. Coastal engineering (draining, dredging, filling, dam building).

What land is left for public recreation should be scrupulously managed to maintain the ecological balance, as well as protect the interests of the seaside vacationer.

Underwater parks are a recent development which can expand the recreational (and educational) use of a seaside park.

*RECREATION FACILITIES, *UNDERWATER, *SEASHORES, *LAND USE, *NATIONAL SEASHORES, natural resources, ecology, management, coastal engineering, engineering, water pollution, parks, coasts, shores, resources

172. Hatch, Richard W., "ECOLOGICAL CONSIDERATIONS: SEA AND SHORE", in THE MAINE COAST--PROSPECTS AND PERSPECTIVES, October, 1966, pp. 29-34. Center for Resource Studies, Bowdoin College, Brunswick, Maine.

The author identifies three stages of human development in which man affects the ecological balance of an estuary: (1) agriculture, (2) industrial development, and (3) urbanization.

The immediate effects of those frequently-overlapping stages are listed:

1. Agriculture: accelerated development of mud flats and tidal marshes, nutrient enrichment from manure causing algae growth, and pesticides.

2. Industrial development: toxic chemical pollutants, organic wastes with high oxygen demand, suspended organic matter, and thermal pollution causing increased bacterial activity.

3. Urbanization: dumping of domestic sewage, drainage, dumping of solid waste, filling, dredging, and highway construction.

*WATER POLLUTION SOURCES, *MAINE, *URBANIZATION, *BALANCE OF NATURE, *INDUSTRIES, *AGRICULTURE, geographical regions, regions, New England, northeast U. S., coasts

173. Hedgpeth, Joel W., "ASPECTS OF THE ESTUARINE ECOSYSTEM", in MARINE, ESTUARIAN, AND RIPARIAN POLLUTION DISASTERS AND THEIR CONSEQUENCES, Ocean Resources Subcommittee Meeting, December 13, 1967. National Security Industrial Association, Washington, D. C.

Among the characteristics of the estuarine ecosystem are the occurrence of closely related species adjusted to the seasonal and nutrient cycles of the estuary, the seasonal replacement of various mass species, and the integrating effect induced by large populations of benthic mollusks, especially oysters and mussels. It is suggested that such a value as gross photosynthesis is not a good indicator in itself of the state of this complex system. Factors causing the decline of productivity and ecological health of several major estuarine ecosystems are discussed; these declines are primarily due to such works of man as alteration of river flow, changing shorelines by filling, and pollution.

*BALANCE OF NATURE, *ECOSYSTEMS, river flow, water pollution effects, channel flow, water pollution, environmental effects, mollusks, animals, aquatic animals, aquatic life, invertebrates, benthic fauna, benthos, flow, estuarine environment, aquatic environment, environment

174. Heinemann, G., COOLING WITH SEAWATER, Chemical Engineering, Vol. 70, No. 12, June 10, 1963, pp. 188-189.

It is expected that the use of sea water for cooling should increase as the supply of fresh water becomes more and more limited. This article discusses materials for use in systems using sea water and water from tidal basins. The use of chlorine to prevent the growth of organisms in these systems is also discussed.

*COOLING, *SEA WATER, *CHLORINATION, cooling water, saline water, water types, chemical reactions, tidal waters

175. Hellier, Thomas R., Jr., and Louis S. Kornicker, SEDIMENTATION FROM A HYDRAULIC DREDGE IN A BAY, Institute of Marine Science, Vol. 7, 1962, pp. 212-215.

Red gravel was used to mark the movement of sediment after the dredging of a section of an intercoastal waterway near Arkansas Pass, Texas. The spoil was placed in "spoil banks". Eighteen months later a negligible amount of silt had by-passed the spoil island or was eroded from the island.

*DREDGING, *SILTS, *SPOIL BANKS, *SEDIMENT TRANSPORT, *GULF COASTAL PLAINS, channel improvement, fine textured soils, pervious soils, soil types, Texas, central U. S., coastal plains, geographical regions, regions, southwest U. S., inland waterways, channels

176. Henderson, John M., "STATEMENT", in CLEAN WATER FOR THE NATION'S ESTUARIES, Proceedings of the Georgia Public Meeting, Jekyll Island, Georgia, February 29, 1968, p. 9. Federal Water Pollution Control Administration, Department of the Interior, S. E. Region, Atlanta, Georgia.

This paper is concerned with filth-borne (enteric) disease occurrence and related procedures and standards for determining the safety of estuarine waters for recreational use or shellfish growing. The term "filth-borne (enteric)" disease is intended to include all diseases contracted as a result of sewage pollution or other fecal pollution and not merely those diseases which are confined to the gastro-intestinal tract of man.

These two subjects, recreational water use and shellfish production and consumption, have points in common and also distinct differences between them as they relate to human disease.

*WATER POLLUTION EFFECTS, *ENTERIC BACTERIA, *DISEASES, *RECREATION, "SHELLFISH, "COMMERCIAL FISHING, water quality, sewage bacteria, sewage effluents, bacteria, microorganisms, plants, effluents, aquatic animals, aquatic life, animals, fishing, industries

177. Hetling, L. J., A MATHEMATICAL MODEL FOR THE POTOMAC RIVER--WHAT IT HAS DONE AND WHAT IT CAN DO, 1966 Fall Meeting of the Interstate Commission on the Potomac River Basin, St. Mary's City, Maryland, Federal Water Pollution Control Administration, CB-SRBP Technical Paper No. 8, September 22, 1966.

This paper presents the use of Thomann's mathematical model for comprehensive water pollution control program of the Potomac Estuary in Washington Metropolitan Area. Various graphs show the dye, chloride, and dissolved oxygen distribution in the Upper Potomac Estuary. The effect of BOD input removal upon the minimum dissolved oxygen level for three fresh water flow conditions is shown.

*MATHEMATICAL MODELS, *RIVERS, *DYE RELEASES, *CHLORIDES, *DISSOLVED OXYGEN, *DISTRICT OF COLUMBIA, oxygen demand, mathematical studies, model studies, biochemical oxygen demand, streams, bodies of water, channel flow, streamflow, running waters, surface waters, halides, water pollution control, river flow, flow

178. Hetling, L. J., and R. L. O'Connell, A STUDY OF TIDAL DISPERSION IN THE POTOMAC RIVER, 1966 Fall Meeting of the Interstate Commission on the Potomac River Basin, St. Mary's City, Maryland, Federal Water Pollution Control Administration, CB-SRBP Technical Paper No. 7, September 22, 1966.

A dye tracer study was carried out for a 34-day period from June 10 to July 14, 1965, to mathematically describe the fate of pollutants entering the tidal system. Thomann's mathematical model was used. Dye loss rate, dye discharge rate, and dye concentrations along the estuary are plotted in various figures. The dispersion coefficient varied along the length of the estuary and is plotted against the distance in miles from Chain Bridge.

*DYE RELEASES, *MATHEMATICAL MODELS, *TIDAL WATERS, *TRACERS, *PATH OF POLLUTANTS, mathematical studies, model studies, dispersion, geographical regions, coastal plains, Maryland, Virginia, Appalachian Mountain region, regions, northeast U. S., southeast U. S., Atlantic coastal plain

179. Hoffman, Carl P., Jr., and Donald S. Fitzgibbon, REPORT ON THE 1961 TRANSPORTATION RESEARCH AND SERVICE ACTIVITIES OF THE BUREAU OF COMMERCIAL FISHERIES, Branch of Economics, Bureau of Commercial Fisheries, Washington, D. C., Report No. 544, June, 1962.

The activities reported upon include (1) participation in regulatory proceedings and (2) negotiations with carriers to obtain improvements in transportation rates, services, and facilities for the fishing industry. The research activities of the Transportation Section involve collection and analysis of financial and traffic data and study of the methods used in moving, terminal handling, packing, and storing of fish and shellfish. The work is carried on by the Transportation Section staff, by other Government agencies, and by private firms working under contract.

*TRANSPORTATION, *COMMERCIAL FISHING, *FEDERAL GOVERNMENT, fishing, industries, data collections, statistics, financial analysis, analytical techniques, commercial fish, animals, aquatic animals, aquatic life, fish, wildlife, commercial shellfish, invertebrates, shellfish, costs, regulation, negotiations, storage

180. Hollis, Edgar H., "COMMERCIAL AND SPORT FISHERIES", in PROBLEMS OF THE POTOMAC ESTUARY, January, 1964, pp. 23-27. Interstate Commission on the Potomac River Basin, Washington, D. C.

A general discussion of the fisheries of the Potomac Estuary is presented. The report contains estimates of the production capability of commercial fisheries, their value to the Potomac River and its tributaries during recent years, and estimates of the number of people participating in the commercial fishery. Estimates of sport fishing usage and catch based on surveys conducted in 1960 and 1961 by the Natural Resources Institute are given. It concludes that the commercial production of crabs and finfish in the Potomac Estuary is of a sizeable magnitude and in all probability can be maintained at the existing or at a slightly increased level for a long period of time. However, because of the economic conditions and trends generally prevailing in the inshore fishing industry, prospects for increasing the production and values for commercial species in the Potomac Estuary do not appear as great as for the other resources.

*MARYLAND, *VIRGINIA, *SPORT FISHING, *COMMERCIAL FISHING, *PRODUCTIVITY, personnel, market value, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions, commercial shellfish, crustaceans, invertebrates, fish, shellfish, wildlife, southeast U. S., statistics, data collections, crabs, finfish, fishing, industries, recreation, water sports, animals, aquatic animals, aquatic life

181. Holmsen, Andreas, THE RHODE ISLAND QUAHOG INDUSTRY--SOME ECONOMIC ASPECTS, Rhode Island Agricultural Experiment Station Bulletin, No. 386, 1966.

The purpose of the study was to (1) examine the economics of handraking and dredging, (2) describe the dealer's functions and the competition in the industry, (3) analyze the price behavior in the market, including funds and seasonal variations in prices, and (4) to indicate more effective ways to utilize the resource.

More people are engaged in handraking than in dredging, with all age groups represented. One-third of the handrakers are over 50 years of age, although most are not employed full-time. If, however, more areas were opened for power dredging, it would affect the labor force such that a significant number of people over 50 years old would have difficulty finding employment elsewhere. The net return to the clammer from handraking is $2.84 per hour.

Figures are provided for power dredging but are not comparable with handraking figures because of the different methods used to obtain them. This is due primarily to variation in labor force. The average return to a dredge boat owner is $41 per day.

Possible ways to improve the industry are suggested.

*RHODE ISLAND, *CLAMS, *COST COMPARISONS, *HARVESTING, commercial shellfish, prices, environmental sanitation, animals, aquatic animals, aquatic life, benthic fauna, benthos, invertebrates, mollusks, shellfish, geographical regions, New England, northeast U. S., regions, analysis, cost analysis, mathematical studies, water pollution effects, water pollution.

182. Holmsen, Andreas, and Joseph Stanislao, ECONOMICS OF QUAHOG DEPURATION, Rhode Island Agricultural Experiment Station Bulletin, No. 384, 1966, pp. 1-36.

This study deals with the technical and economic aspects of depuration, including the design of a processing plant, the design of equipment, and an analysis of the economic feasibility of this method as compared with the present method of transplanting organisms from polluted to clean waters as these factors concern quahogs in Rhode Island. The cost of transplanting clams is discussed and compared with the cost of depurating a like number of clams. In addition, a cost analysis is given for the development and operation of a complete depuration plant. It is estimated that the cost of depuration by use of ultraviolet light exclusive of other processing for a plant with a capacity of 105,000 bushels per year, which is Rhode Island's estimated annual yield in moderately polluted waters, is 25.4¢ per bushel, as compared to the cost of about $1.85 per bushel when the clams are transplanted to unpolluted water.

*CLAMS, *RHODE ISLAND, *WATER POLLUTION EFFECTS, *COST COMPARISONS, cost analysis, animals, aquatic animals, aquatic life, benthic fauna, benthos, commercial shellfish, invertebrates, mollusks, shellfish, analysis, mathematical studies, water pollution, geographical regions, New England, northeast U. S., regions

183. Howard, R. S., "GEORGIA WATER QUALITY CONTROL BOARDS STATEMENT TO THE NATIONAL ESTUARINE STUDY REPORT", in CLEAN WATER FOR THE NATION'S ESTUARIES, Proceedings of the Georgia Public Meeting, Jekyll Island, Georgia, February 29, 1968, pp. 1-4. Federal Water Pollution Control Administration, Department of the Interior, S. E. Region, Atlanta, Georgia.

Georgia has 2000 square miles of estuarine zone (including salt marshes) on 115 miles of seacoast.

Seafood production has declined drastically in the last 40 years due to contamination and pollution from sewage and industrial pollution.

The State Water Quality Control Board makes the following recommendations for the preservation of estuarine water quality:

1. Federal and state governments should clean up existing pollution from sewage and industrial wastes,
2. Undertake research on the effects of pollutants, from sewage and industrial wastes, on the marine biota of estuaries,
3. Investigate the possibility of blending certain waste discharges to offset individual pollutional effects,
4. Conduct social and economic studies to develop the values of estuaries for various uses and for aesthetic considerations, and determine the practicality of the zoning concept as opposed to the multiple use philosophy,
5. Establish a pesticide monitoring and sampling program, especially through the spring and summer seasons,
6. Develop a shellfish and fish sampling program to study the effects of radiation and pesticides on fish, shellfish, and other marine life, and
7. Determine the volume and patterns of flows in tidal basins.

*WATER QUALITY CONTROL, *GEORGIA, *POLLUTION ABATEMENT, *SEWAGE TREATMENT, *INDUSTRIAL WASTES, *LEGISLATION, radioactivity effects, fish, shellfish, water pollution treatment, water treatment, control, quality control, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, regions, southeast U. S., zoning, toxicity, pesticides, marshes, wetlands, abatement, waste treatment, tidal marshes, social values, wastes, economic impact, values, aesthetics

184. Howe, Henry, SALT RIVERS OF THE MASSACHUSETTS SHORE, 1951. Holt, Rinehart, and Winston, Inc., New York.

The work begins with a geological description of the formation of the area. It chronologically traces the use of the facilities from the early settlement for economic activities such as shipping, milling, fishing, saltworks, shipbuilding. It follows the rise to power of communities in given fields, e.g. New Bedford's whaling days. Howe compares and parallels growth and development of several estuary-based community economies in Massachusetts.

The existence of estuaries did not directly cause industrialism, but rather stimulated its growth through the availability of water power, inland water transportation, canal links, and manpower.

The Merrimack River and Buzzards' Bay are studied in detail.

*HISTORY, *MASSACHUSETTS, *INDUSTRIES, *RIVERS, community development, economic life, geology, commercial fishing, fishing, shores, ships, bodies of water, running waters, streams, surface waters, geographical regions, New England, northeast U. S., regions

185. Hull, C. H. J., OXYGENATION OF BALTIMORE HARBOR BY PLANKTONIC ALGAE, Water Pollution Control Federation, Journal, Vol. 35, No. 5, 1963, pp. 587-606.

This paper discusses the contribution of photosynthesis to the oxygen balance and, hence, the waste assimilative capacity of an estuary. A literature review is included. A detailed report is given of the effect of photosynthesis upon the waste assimilative capacity of Baltimore Harbor. Data were collected and analyzed indicating quantities of oxygen produced, but the results were not interpreted directly to provide a measure of overall waste assimilation capacity. It was concluded, however, that the contribution of photosynthesis is greater than is that of reaeration.

*PHOTOSYNTHESIS, *REAERATION, *WASTE ASSIMILATIVE CAPACITY, *OXYGEN REQUIREMENTS, *MARYLAND, self-purification, water purification, water treatment, oxygenation, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions, harbors

186. Huston, John W., THE OYSTER AND THE DREDGE OR "BEAUTY AND THE BEAST", World Dredging and Marine Construction, Vol. 4, No. 2, March, 1968, pp. 30-31.

The author refutes complaints made by oyster fishermen on the effects of dredging on oyster beds. Points covered are: toxicity, chemical changes, turbidity, effect on life cycle, siltation, and physiological irritation.

*OYSTERS, *DREDGING, *ECOLOGY, *AQUATIC HABITATS, animals, aquatic animals, aquatic life, benthic fauna, benthos, commercial shellfish, invertebrates, marine animals, habitats, environment, mollusks, shellfish, silting, sedimentation, toxicity, turbidity, physical properties, life cycles, physiological ecology

187. Hutton, Robert F., Bonnie Eldred, Kenneth P. Woodburn, and Robert M. Ingle, THE ECOLOGY OF BOCA CIEGA BAY WITH SPECIAL REFERENCE TO DREDGING AND FILLING OPERATIONS, PART I, Florida State Board of Conservation Marine Laboratory, St. Petersburg, Florida, March 21, 1956.

This report contains sundry data relating to the physical and biological characteristics of Boca Ciega Bay, including temperature, rainfall, salinity, currents, pH of Bay waters, tides, tidal bench works, listing and descriptions of flora and fauna, etc. Also included are estimates of the number of tourist visits, tourist expenditures, and the number of lodging enterprises which accommodated tourists (and presumably non-tourists also) in 1954. Estimates of business volume of one bait-shrimp dealer, 17 boat dealers and boat repair shops, and four commercial fish dealers in the area are listed. Qualitative conclusions are reached regarding the effects of dredge and fill operations on resource values.

*DREDGING, *ECOLOGY, *BAYS, *FLORIDA, *ECONOMIC IMPACT, landfills, commercial fishing, sport fishing, bodies of water, Atlantic coastal plain, coastal plains, geographical regions, regions, southeast U. S., fishing, industries, recreation, water sports, aquatic animals, aquatic plants, animals, aquatic life, plants, tourism, water properties, value

188. Hynes, H. B. N., THE BIOLOGY OF POLLUTED WATERS, 1960. Liverpool University Press, Liverpool, England.

This comprehensive treatment of the biology of polluted waters "has summarized and codified the information that is available". The book is largely limited to fresh water, and gives very little consideration to the biology of polluted estuarine waters. With regard to estuarine waters the author concludes that, "Apart from the effect on migratory fishes there is little detailed information on the biological consequences of estuarine pollution". The book was evidently written for ready comprehension of the basic principles by the lay reader, and would provide an admirable basic text for the subject of water pollution.

*WATER POLLUTION EFFECTS, *BIOLOGICAL COMMUNITIES, *ECOLOGY, water pollution, aquatic environment, aquatic microbiology, impaired water quality, pollutants, water quality, environment, microbiology, aquatic plants, aquatic life, plants, aquatic animals, animals, aquatic habitats, habitats

189. Iles, R. B., CULTIVATING FISH FOR FOOD AND SPORT IN POWER-STATION WATER, New Scientist, No. 324, January, 1963.

The beneficial uses of thermal pollution for fish culture and recreational use are discussed. The possibility of raising of a number of non-indigenous species and ornamental fish in heated effluent is discussed. The author argues that British waters are generally too cold during the winter season to closely approach optimum productivity of fish growth.

*THERMAL POLLUTION, *BENEFICIAL USE, *HEATED WATER, *WASTE WATER (POLLUTION), *FISH STOCKING, thermal power, fish farming, water sports, sport fishing, water pollution, foreign countries, geographical regions, regions, water types, effluents, liquids, liquid wastes, wastes, agriculture, stocking, fish establishment, recreation, fishing

190. INDEX OF SELECTED OUTDOOR RECREATION LITERATURE, VOLUME II, Department of the Interior, Bureau of Outdoor Recreation, Washington, D. C., Report No. 7000-70847, March, 1968.

This is a compilation of abstracts of articles, books, conference proceedings, directories, documents, reports, speeches, yearbooks, and bibliographies of outdoor recreation literature.

*ABSTRACTS, *RECREATION, documentation, bibliographies

191. INLAND WATER-BORNE COMMERCE STATISTICS 1965, The American Waterways Operators, Inc., Washington, D. C., June, 1967.

The data in this report on commodities transported over the inland waterways of the U. S. (including Chesapeake Bay, Delaware River, James River, and Potomac River) are compiled from statistics issued by the waterborne commerce statistics center of the Army Corps of Engineers.

Included are reports on 27 major waterways showing the lengths of the navigable sections, controlling depths, comparisons of the total annual traffic for the last five years, and the net tons of major commodities transported in 1965.

This report is issued annually.

*RIVERS, *TRANSPORTATION, *STATISTICS, *INLAND WATERWAYS, bays, data collections, channels

192. INTERIM REPORT ON GROSS PHYSICAL AND BIOLOGICAL EFFECTS OF OVERBOARD SPOIL DISPOSAL, Chesapeake Biological Laboratory, Natural Resources Institute, University of Maryland, Ref. No. 67-34, May, 1967.

This interim report describes the effects associated with 1966 channel dredging in Chesapeake Bay. The effects considered were on geology and hydrography, phytoplankton, benthos, zooplankton, fish eggs and larvae, and adult fish. Observed effects of the disposal were summarized by the authors as:

1. Fine sediments from the channel were released in shoal water, over similar sediments, as a semi-liquid mixture.
2. Sediments were spread over an area at least five times as large as the designated disposal area.
3. There was a highly localized release of nutrient chemicals, roughly equivalent to a sewer outfall from a town of about 10,000 people.
4. No gross effect was observed on the microscopic plants and animals in the water, nor on the eggs and larvae of fish, nor on adult fish held in cages near the outfall or caught near the area.
5. Some bottom animals were smothered over a wide area, so that a significant loss occurred. Some species survived deposition, and certain species began repopulation soon after deposition.

*SEDIMENTS, *DREDGING, *WATER POLLUTION EFFECTS, *AQUATIC PLANTS, *AQUATIC ANIMALS, sediment control, growth stages, fish eggs, channel improvement, hydrography, geology, phytoplankton, zooplankton, larvae, eggs, fish, bays, bodies of water, Maryland, Appalachian Mountain region, sediment discharge, control, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions, hydrologic aspects, aquatic life, plankton, plants, animals, benthos

193. INVESTIGATION OF THE INTERNATIONAL PASSAMAQUODDY TIDAL PROJECT, International Joint Commission of the Passamaquoddy Tidal Project, Docket No. 72, April, 1961.

This report presents the detailed results of an investigation by the International Joint Commission of the Passamaquoddy Tidal Power Project.

In finding that the Passamaquoddy tidal power project is not economically feasible, the Commission recommended that development of the project be viewed as a long-range possibility having better prospects of realization when other energy resources available are exhausted. The Commission points out that the economic feasibility of the project may be affected by future changes in the costs and benefits considered in the present evaluation of the project. Consideration of the desirability of crediting the tidal project with certain public benefits that have not been included in the economic feasibility determination presented in this report was identified as a possibility.

The Commission also recommends that this report be made available to interested parties as a valuable source of relevant engineering and economic data for use in any future study of the possibilities for development of the international tidal power potential of Passamaquoddy Bay.

*ELECTRIC POWER, *COST-BENEFIT ANALYSIS, *TIDAL POWERPLANTS, *ECONOMIC FEASIBILITY, tidal energy, energy, electric powerplants, engineering structures, industrial plants, powerplants, structures, feasibility, indirect benefits, benefits

194. Isaac, Gary W., and Curtis P. Leiser, SEATTLE'S EFFORTS IN RESTORATION OF BAYS AND ESTUARIES, 32nd North American Wildlife and Natural Resources Conference, San Francisco, California, Transactions, March 13-15, 1967, pp. 127-137.

Citizens in the Seattle area, which is comprised of 14 cities, initiated the legislation and voted into being a metropolitan municipal corporation, specifically to deal with the pollution problem, but able also to expand to alleviate other regional difficulties as they would arise.

An operating treatment agency and four engineering firms composed a master plan which is detailed in this paper. The cost of the plan was estimated at $125,000,000.

The pollution control program will continue in three major parts:

1. Emission controls applied to industrial waste discharges at the source.
2. Treatment plant control and monitoring by personnel attached permanently to plant operations.
3. A separate force to monitor the receiving waters for biological nutrient and physical parameters.

*WASHINGTON, *SEWAGE TREATMENT, *WATER POLLUTION CONTROL, Pacific northwest U. S., civil engineering, waste treatment, engineering, algae, plants, control, pollution abatement, abatement, Pacific coast region, regions, geographical regions, bays, bodies of water.

195. Jeffries, H. P., ENVIRONMENTAL CHARACTERISTICS OF RARITAN BAY, A POLLUTED ESTUARY, Limnology and Oceanography, Vol. 7, 1962, pp. 21-31.

Temperature, salinity, dissolved O_2, PO_4-P, and NO_3-N in Raritan Bay, New Jersey, were determined over a 16-month period. Each reflects the circulation pattern in which sea water floods along the northern shore, enters a region of mixing with river discharge in the head of the bay, and then ebbs out along the southern shore. A combination of rich nutrient supplies arising from natural and domestic sources, plus a sluggish circulation, efficient nutrient regeneration mechanism, and scarcity of macroscopic algae combine to form an estuarine environment capable of supporting extremely dense plankton populations.

*SALINITY, *DISSOLVED OXYGEN, *NUTRIENTS, *NEW JERSEY, *WATER CIRCULATION, temperature, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., circulation, eutrophication

196. Jenkins, Allston, TESTIMONY - PHILADELPHIA CONSERVATIONISTS, INC., Estuarine Hearings, Subcommittee on Fisheries and Wildlife Conservation of the Committee on Merchants Marine and Fisheries, House of Representatives, 90th Congress, Serial No. 90-3, March, 1967.

Five case histories of estuarine despoliation in the Delaware River estuary are presented. Case histories discussed include: (1) construction for refineries, (2) dock and berthing facilities, (3) acquisition of land for a refinery tank farm and unloading facilities, and (4) acquisition of land for constructing a nuclear energy plant.

*DREDGING, *ESTUARINE ENVIRONMENT, *INDUSTRIAL PLANTS, *INDUSTRIAL WATER, *DELAWARE RIVER, electric powerplants, powerplants, aquatic environment, environments, conservation, buildings, engineering structures, structures, docks, nuclear powerplants, bodies of water, interstate rivers, rivers, running waters, streams, surface waters, Delaware River Basin Commission, interstate commissions, river basin commissions, water types

197. Jenkins, William A., "U. S. COAST GUARD REPORT OF WAKE ISLAND OIL SPILL", in MARINE, ESTUARIAN, AND RIPARIAN POLLUTION DISASTERS AND THEIR CONSEQUENCES, Ocean Resources Subcommittee Meeting, December 12, 1967. National Security Industrial Association, Washington, D. C

The Wake Island oil spill is described in great detail. All the repercussions of this disaster are discussed: (1) air pollution, (2) shoreline pollution, and (3) small boat harbor pollution.

The problem was alleviated by the passage of a typhoon which scoured away much of the polluted area.

*OIL WASTES, *DISASTERS, *FOREIGN COUNTRIES, *WATER POLLUTION, beaches, air pollution, environmental effects, geographical regions, regions, organic matter, wastes

198. Jensen, P. T., and P. G. Swartzell, CALIFORNIA SALMON LANDINGS, 1952 THROUGH 1965, Fishery Bulletin, Vol. 135, 1967, pp. 43-57.

Trends in landings and dollar values of salmon landed both commercially and by sport fishermen in California ports are provided for the years 1952-1965.

*SALMON, *MARKET VALUE, *FISH HARVEST, *CALIFORNIA, commercial fishing, sport fish, fishing, industries, animals, aquatic animals, aquatic life, fish, wildlife, sport fishing, recreation, water sports, salmonids, income, return (monetary), value, geographical regions, Pacific coast region, regions, southwest U. S.

199. Kalman, P., ECONOMIC ASPECTS OF GAME FISHING ON THE NORTHERN GULF OF MEXICO, 11th International Game Fish Conference (1966), Proceedings, August, 1967, pp. 19-29.

The author states that the national average expenditure for salt water fishermen is $96.00 annually, or $8.34 per fishing day. Approximately 22 percent of the angler's dollar is spent on bait, guides, and fee for charter boats. Equipment other than fishing gear accounts for 26.9 percent. Transportation to and from the fishing grounds accounts for about 14.7 percent, and food and lodging total about 15.2 percent. Fishing gear accounts for 11 percent of the dollar and licenses and fees make up 5 percent. Dollar values are provided for most of the Gulf States.

The author also presents information on expenditures by salt-water fishermen and charter boat operators which is virtually unavailable elsewhere in the literature. This includes: charter boat fees; charter boat expenses, i. e., costs of boats, engines, maintenance, fuel, labor, bait, and insurance; sales of fish by charter boat operators; and expenditures per fish-catch for deep sea sports fish.

*SPORT FISHING, *COST ANALYSIS, *GULF OF MEXICO, recreation, marine fisheries, fishing, fisheries, water sports, fishing gear, analysis, mathematical studies, equipment, boats, bodies of water, gulfs, surface waters

200. Kastrop, J. E., and J. Scott, INDUSTRY OUTLOOK/DIRECTION 1968, Petroleum Engineer, Vol. 40, No. 1, January, 1968, pp. 49-61.

United States demand figures for oil and gas are related to known reserves. Drilling rig figures are tabulated showing types and numbers, depths and costs. Problems and location costs are discussed.

*OIL INDUSTRY, *OIL RESERVOIRS, *DEMAND, *COSTS, secondary recovery (oil), flooding, injection, industries, drilling, natural gas, gases, organic compounds

201. KEEPING OIL OUT OF THE SEA, Ocean Industry, Vol. 2, No. 11, November, 1967, pp. 10-16.

The authors discuss various sources of oil pollution: tankerballast and bilges, tanker disasters, sunken tankers, natural oil seeps. Also discussed are various means of combating oil spillage and ways of improving oil transporting.

*WATER POLLUTION SOURCES, *OILY WATER, *OIL WASTES, *SHIPS, oil industry, industries, organic matter, wastes, transportation, oil

202. Kelleher, Thomas F., "BOAT AND MARINA WASTES", in PROBLEMS OF THE POTOMAC ESTUARY, January, 1964, pp. 60-63. Interstate Commission on the Potomac River Basin, Washington, D. C.

Estimates are given for the number of marinas presently in operation in the U. S., their business volume, and the number of people participating in recreational boating. Efforts of the "boating fraternity" to obtain better pollution control through legislation, research and development, and education are described. A list of conclusions regarding desirable water-quality control programs involving pleasure boats and marinas is included. One significant conclusion is that state and local laws must be sufficiently uniform to permit boat owners and operators to travel from state to state without being challenged on waste treatment equipment aboard.

*MARYLAND, *VIRGINIA, *WATER POLLUTION CONTROL, *MARINAS, *RECREATION WASTES, *LEGISLATION, *WATER QUALITY CONTROL, water pollution sources, recreation facilities, boating, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions, southeast U. S., recreation, wastes, water sports, control, quality control, income

203. Kelley, D. W., and Jerry L. Turner, FISHERIES PROTECTING AND ENHANCEMENT WITH WATER DEVELOPMENT OF THE SACRAMENTO-SAN JOAQUIN ESTUARY, A Symposium on Estuarine Fisheries, American Fisheries Society, Special Publication No. 3, 1966, pp. 78-82.

The development of a water plan through the joint efforts of biologists and engineers, "...that appears compatible with other uses of the estuary and that provides opportunities to protect and perhaps enhance the fisheries resources" is presented. The plan relates to the transfer of Northern California waters to Southern California, with respect to water in transit through the delta area. The estuary and its fish and fisheries are described. Estimates are presented of annual sport-fishing expenditures, sport-fish catch, and angler days in the estuary and adjacent areas.

*CALIFORNIA, *WATER RESOURCES DEVELOPMENT, *ESTUARIES, sport fishing, geographical regions, Pacific coast region, regions, southwest U. S., fishing, recreation, water sports, resource development, bodies of water, area redevelopment, conservation, natural resources, resources, reclamation, coastal engineering, engineering, social participation, water utilization, coastal plains, surface waters

204. Kenney, Nathaniel T., CHESAPEAKE COUNTRY, National Geographic, Vol. 126, No. 3, September, 1964, pp. 370-411.

This article lightly covers social and economic forces behind the development of Chesapeake Bay.

*MARYLAND, *HISTORY, *SOCIAL IMPACT, *ECONOMIC IMPACT, *BAYS, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions, social aspects, bodies of water

205. Kerri, Kenneth D., A DYNAMIC MODEL FOR WATER QUALITY CONTROL, Water Pollution Control Federation, Journal, Vol. 39, No. 5, May, 1967, pp. 772-786.

The author proposes formation of an association to study the problem of waste discharges with an objective of achieving and maintaining water quality objectives at a minimum cost of waste treatment. He argues that such an association might provide a smooth transition from current American practice to a water pollution control system based on economic analysis. Arguments with quantitative conclusions based on operation of a model of the Willamette River in Oregon are given. Advantages and disadvantages are discussed, and the idea is compared briefly with German practice. While based on river basin analysis, the concepts involved should be applicable to estuaries, at least in part.

*WASTE WATER TREATMENT, *ORGANIZATIONS, *COST COMPARISONS, *OREGON, systems analysis, economic efficiency, economies of scale, water quality control, quality control, foreign countries, geographical regions, Pacific coast region, Pacific northwest U. S., regions, control

206. Kerri, Kenneth D., AN ECONOMIC APPROACH TO WATER QUALITY CONTROL, Water Pollution Control Federation Journal, Vol. 38, No. 12, December, 1966, pp. 1883-1897.

The author presents an economic model designed to produce the minimum cost of achieving a water quality objective by analyzing costs of treating waste discharges and the natural purification capacity of the receiving waters. The model determines the degree of treatment required of each waste discharge in order to achieve a desired water quality objective at the minimum cost to all discharges in the affected region.

Actual input and output data are given for its use on the Willamette River in Oregon, and the costs of meeting given dissolved oxygen objectives by various alternatives and constraints are compared. Stream standards are found to be far superior to effluent standards in terms of total costs of obtaining a given DO objective.

While the model relates to a river, the concepts involved in the model are relevant to estuaries to a substantial degree.

*WATER MANAGEMENT (APPLIED), *WATER QUALITY CONTROL, *OREGON, *WASTE WATER TREATMENT, *MODEL STUDIES, methodology, waste disposal, control, quality control, management, geographical regions, Pacific coast region, Pacific northwest U. S., regions, waste treatment, water treatment.

207. Ketchum, B. H., DISTRIBUTION OF COLIFORM BACTERIA AND OTHER POLLUTION IN TIDAL ESTUARIES, Sewage and Industrial Wastes, Vol. 27, No. 11, November, 1955, pp. 1288-1296.

This paper presents a method for predicting the distribution of coliform bacteria and other pollutants in estuaries. It discusses the distribution of conservative pollutants, those which do not change with time, and nonconservative or "time variable" pollutants. The author demonstrates that the steady-state distribution of a conservative pollutant is directly related to the distribution of fresh and salt water, and that the distribution can be derived from the results of a salinity survey of the estuary.

Pollutants which decay or decrease with time are less concentrated everywhere in the estuary than are the concentrations of conservative pollutants. Like the conservative pollutant, the upstream concentration of a nonconservative pollutant can be reduced by a downstream displacement of the outfall. In contrast to the conservative pollutant, the downstream concentration can be reduced by an upstream displacement of the outfall. Mathematical relationships for predicting pollutant concentrations in terms of relevant parameters are provided.

*POLLUTANTS, *TIDAL WATERS, *OUTLETS, *COLIFORMS, *FORECASTING, *DISTRIBUTION PATTERNS, mathematical models, mathematical studies, model studies, salinity, chemical properties, water properties, bacteria, plants, microorganisms

208. Ketchum, B. H., THE FLUSHING OF TIDAL ESTUARIES, Sewage and Industrial Wastes, Vol. 23, No. 2, 1951, pp. 198-209.

The author presents a method for calculating the effective dilution of fresh water entering an estuary. A means for determining the ratio of fresh-to-salt water at any location in the estuary is also presented. This ratio yields selected physical characteristics of the estuary, the rate of river flow, and the position of the tide. The author's analysis indicates fallacies inherent in the tidal-prism theory. The author neglects, however, the effects of stratification and due to density differences resulting from salt concentration and temperature gradients.

*DILUTION, *SALINE WATER, *MATHEMATICAL STUDIES, *FRESH WATER, mixing, saline water-freshwater interfaces, boundaries (surfaces), interfaces, river flow, tides, water types, channel flow, flow, stream flow

209. Ketchum, Bostwick H., THE EXCHANGES OF FRESH AND SALT WATERS IN TIDAL ESTUARIES, Journal of Marine Research, Vol. 10, No. 1, 1951, pp. 18-38.

An empirical theory is presented which describes the exchanges between various parts of an estuary as a result of tidal oscillations, and which permits the calculation of the average distribution of fresh and salt water within the estuary. The characteristics of the estuary used in the calculation are the mean range of tides, the river flow, and the topography. The calculated distributions of river water are compared with three different estuaries, Raritan River and Bay, Alberni Inlet, and Great Pond. The theoretical results correspond closely with observed distributions of salinity and fresh water in all three estuaries.

*DISPERSION, *SALINITY, *MATHEMATICAL STUDIES, *SALINE WATER-FRESHWATER INTERFACES, surface waters, river flow, channel flow, stream flow, inlets (waterways), bodies of water, running waters, streams, New Jersey, Washington, bays, ponds, lakes, Massachusetts, chemical properties, topography, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions, New England, water properties, boundaries (surfaces), interfaces, tides

210. Ketchum, Bostwick, H., MARINE POLLUTION PROBLEMS IN THE NORTH ATLANTIC AREA, Biological Problems in Water Pollution, Transactions, No. W60-3, 1959, pp. 212-217.

The purpose of this article is to "discuss briefly the effect of the location of an outfall within an estuary in terms of the dilution potential available and to introduce some of the problems involved in evaluating the disposal of liquid wastes at sea". It makes a basic distinction between conservative and time variable pollutants. Sea disposal is discussed at some length, with particular reference to barging industrial effluent (a solution of ferrous sulfate in 10 percent sulfuric acid) for disposal in the bight off New York City. Findings by another investigator show that one effect of such disposal was "a concentration of bluefish on the boundaries of the disposal area which has, during the past ten years, developed a fishery which did not previously exist". A general conclusion of the author is that "the direct introduction of pollutants into coastal water outside the limits of estuaries offers the advantages of maximum potential dilution and minimal return to the estuary. Increased sea disposal seems one inevitable result of the popular demand for the recovery of recreation facilities and natural resources within the estuaries."

*WATER POLLUTION, *WASTE DILUTION, *ATLANTIC OCEAN, outlets, waste dilution, waste dumps, waste disposal, pollutants, water pollution, oceans, bodies of water, surface waters, industrial wastes, wastes, Appalachian Mountain region, geographical regions, Great Lakes region, northeast U.S., regions, New York

211. Kindsvater, C.E., "STATEMENT", in CLEAN WATER FOR THE NATION'S ESTUARIES, Proceedings of the Georgia Public Meeting, Jekyll Island, Georgia, February 29, 1968, pp. 39-42. Federal Water Pollution Control Administration, Department of the Interior, S.E. Region, Atlanta, Georgia.

Since there is much to be learned about the unique problems of an estuarine resources management program, a large part of such a program must consist of research. Estuarine development may be divided into the following research areas: (1) hydrologic, hydraulic, and geologic factors involved in the development of the physical characteristics; (2) biologic and chemical factors, which influence the physical as well as their ecological characteristics; (3) specific man-made pollutional factors and effects; and (4) socioeconomic and institutional factors resulting from man's occupance of estuarine regions and his utilization of their resources.

*RESOURCE DEVELOPMENT, *ESTUARINE ENVIRONMENT, *ECOLOGY, water resources development, resources development, water pollution control, control, water pollution effects, water pollution sources, hydrologic aspects, geologic investigations, biocontrol, control, chemcontrol, social needs

212. Kinne, O., THE EFFECTS OF TEMPERATURE AND SALINITY ON MARINE AND BRACKISH WATER ANIMALS--I. TEMPERATURE, Oceanographers and Marine Biologists Annual Review, Vol. 1, No. I, 1963, pp. 301-340.

The current literature is reviewed with regard to the effects of temperature and salinity on marine and brackish water animals. It is an ecological approach that includes relevant physiological data but excludes purely biochemical or biophysical aspects. It is noted that a complex correlation exists between salinity and temperature, since various antagonistic and synergistic effects have been identified. An extensive bibliography is provided.

*SALINITY, *TEMPERATURE, *BIBLIOGRAPHIES, *BRACKISH-WATER FISH, *MARINE FISH, ecology, environmental effects, chemical properties, water properties, water pollution, marine animals, animals, aquatic animals, aquatic life, fish, saline water fish, wildlife

213. Klein, Louis, RIVER POLLUTION II, CAUSES AND EFFECTS, 1962. Butterworth and Company, Washington, D.C.

The causes of river pollution and the nature of the various kinds of pollution and their effects upon rivers are described. The international chapter on river pollution is well-documented by the variety of countries from which these references emanate, namely: Great Britain, Germany, Holland, Belgium, France, Switzerland, Denmark, USSR, U.S.A., Argentina, Japan, South Africa, New Zealand, and Israel.

*WATER POLLUTION, *RIVERS, *FOREIGN COUNTRIES, water pollution sources, water pollution effects, bodies of water, running waters, streams, surface waters, geographical regions, regions

214. Klein, Louis, RIVER POLLUTION III, CONTROL, 1966. Butterworth and Company, Washington, D.C.

Volume III of River Pollution deals with control and prevention of river pollution. The chapter on the pollution of tidal and coastal waters deals with the significance and effects of growing pollution at beaches and estuaries. Modern aspects of the control of pollution in a large estuary, based upon the treatment of sewage and industrial wastes, are also described. The present status of pollution and hopes for the future in relation to the growing shortage of water is described in great detail.

*WATER POLLUTION CONTROL, *POLLUTION ABATEMENT, *RIVERS, sewage treatment, industrial wastes, control, abatement, tidal waters, coasts, beaches, bodies of water, running waters, streams, surface waters

215. Kneese, Allen V., SOCIO-ECONOMIC ASPECTS OF WATER QUALITY MANAGEMENT, Water Pollution Control Federation, Journal, Vol. 36, No. 2, February, 1964, pp. 254-262.

The author lists the following concepts as useful in defining the nature of water quality management:

1. A region approach is involved.
2. Multipurpose use is an essential element.
3. Comprehensiveness is essential.
4. A systematic search for alternatives should be involved.
5. Flexible adaptation to existing conditions is necessary.

An important element in analysis of water quality alternatives is imputing values to water quality levels for various uses since many of the benefits derived from enhancement of water quality are not measured in the open market. Difficult problems in imputing values occur with recreation, public health, and the general amenities. Techniques with promise in terms of evaluating recreation are under study. Public health is a more difficult problem.

*WATER QUALITY CONTROL, *SOCIAL ASPECTS, *VALUES, *SOCIAL VALUES, water policy, water pollution, water pollution effects, recreation, public health, benefits, cost-benefit analysis, evaluation, control, quality control

216. Kneese, Allen V., WHAT ARE WE LEARNING FROM ECONOMIC STUDIES OF WATER QUALITY, Engineering Progress, Vol. XXI, No. 6, June, 1967, pp. 5-18.

The author maintains that "economics" is often defined only in narrow terms relating to financial returns. In water resource terms the results are often the assumption that certain benefits fall in the social realm, but are not economic in nature. The author maintains that it is often possible to impute economic values to so-called social benefits and thus evaluate them rigorously.

A review of economic studies on water quality leads the author to the following conclusions: (1) Industrial costs relating to water intake are surprisingly insensitive to the quality of intake water, (2) Poor water intake quality does result in extra costs for municipal use, but these costs are usually small in relation to the cost of upstream treatment, (3) Some evidence exists that reasonable values assigned to recreational use would justify increased treatment, at least in one area studied, (4) Too much emphasis is being placed on physical considerations in water quality management and not enough on economics.

The problems of institutional arrangements needed to implant optimum standards are also discussed.

*WATER POLICY, *WATER QUALITY, *COSTS, *INDUSTRIAL WATER, *INDIRECT BENEFITS, institutional constraints, water pollution effects, economic efficiency, benefits, social aspects, social values, values, water types, constraints, cost analysis, analysis, mathematical studies, cost comparisons, economic impact, recreation

217. Knetsch, Jack L., OUTDOOR RECREATION DEMANDS AND BENEFITS, Land Economics, Vol. 39, No. 4, 1963, pp. 387-396.

The author uses a hypothetical example to demonstrate the construction of demand curves for recreation sites. The analysis is extended to include the effects of time of travel and the availability of close substitutes.

Total recreation value is broken into two sources. The first source represents user benefits which people receive from visits to the area. The second source is the capital investment in land near the recreation site. (Land value benefits could be substantial in the case of provate recreation facilities along estuarine shorelines). Effects of fee collection are also incorporated into the analysis.

*RECREATION DEMAND, *MATHEMATICAL ANALYSIS, *INVESTMENT, *PUBLIC BENEFITS, *VALUE, recreation, economic impact, benefits, demand, analysis, land, property values, shores

218. Knetsch, Jack L., and Robert K. Davis, "COMPARISONS OF METHODS FOR RECREATION EVALUATION", in WATER RESEARCH, 1966, pp. 125-142. Johns Hopkins Press, Baltimore, Maryland.

Methods of evaluating the benefits from outdoor recreation are reviewed. The only methods supported by the authors are those which are based on the concept of willingness to pay for services provided. Three such techniques are elaborated upon:

1. Interview methods, designed to measure recreationists' willingness to pay higher prices for using a recreation site.
2. Use of an interview method to establish willingness to drive additional distances for recreation.
3. Use of a travel-cost method to establish willingness to incur travel costs as actually measured by a count of automobiles at a recreation site.

The three methods gave comparable results when tested on the same recreation area.

*RECREATION DEMAND, *BENEFITS, *COST ANALYSIS, recreation, evaluation, recreation facilities

219. Koch, Pierre, "DISCHARGE OF WASTES INTO THE SEA IN EUROPEAN COASTAL AREAS", in PROCEEDINGS OF THE FIRST INTERNATIONAL CONFERENCE ON WASTE DISPOSAL IN THE MARINE ENVIRONMENT, University of California at Berkeley, 1959, 1960. Pergamon Press, New York.

The author summarizes information on discharge methods and pollution problems in the marine disposal of effluents. Most European countries are covered in this article. The information is based on reports from experts in these countries.

*WASTE DISPOSAL, *FOREIGN COUNTRIES, *COASTS, *WATER POLLUTION EFFECTS, *OCEANS, sanitary engineering, engineering, environmental engineering, geographical regions, regions, bodies of water, surface waters

220. Koenig, Louis, ECONOMIC BOUNDARIES OF SALINE WATER CONVERSION, American Water Works Association, Journal, Vol. 51, No. 7, July, 1959, pp. 845-862.

The author discusses a methodology to select those conditions under which saline water conversion might be economical. Conclusions are reached in relation to the situations where saline water might be an economical alternative. The author concludes, "Saline water conversion is, under present conditions (1959), likely to find a market where relatively small production units are involved...if saline water conversion is ever to make a major contribution to water supply, conversion research should seek methods which give a greater slope to the capacity-cost curve."

*DESALINATION, *COST ANALYSIS, *ECONOMIC FEASIBILITY, demineralization, saline water, separation techniques, water purification, water treatment, water types, analysis, mathematical studies, feasibility

221. Kolessar, M.A., "SOME ENGINEERING ASPECTS OF DISPOSAL OF SEDIMENTS DREDGED FROM BALTIMORE HARBOR", in PROCEEDINGS OF THE INTER-AGENCY SEDIMENTATION CONFERENCE, 1963, Miscellaneous Publication No. 970, June, 1965, pp. 613-618. Department of Agriculture, Washington, D.C.

The soft sediments in the Chesapeake Basin are easy to dredge, but large land areas within reasonable distances to channels are not available. The author discusses a means for simulating settling characteristics of spoil so as to predetermine the amount of material a particular site can contain.

*DREDGING, *SEDIMENT DISTRIBUTION, *HARBORS, *MARYLAND, landfills, sediment control, control, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U.S., regions

222. Kollar, K.L., and August F. Volonte, REGIONAL CONSTRUCTION REQUIREMENTS FOR WATER AND WASTEWATER FACILITIES 1955-1967-1980, U.S. Department of Commerce, Business and Defense Services Administration, Water Industries and Engineering Services Division, October, 1967.

This study provides historical construction-cost data from 1955 to 1966 and a projection of requirements from 1967 to 1980. Population projections and wastewater investment requirements by major census regions are given. A breakdown by investment requirements for collection systems, treatment plants, and treatment plant equipment is included.

*WASTE WATER TREATMENT, *INVESTMENT, *FORECASTING, *CONSTRUCTION COSTS, waste treatment, water treatment, costs, treatment facilities

223. Kothandarman, Veerasamy, PROBABILISTIC ANALYSIS OF WASTE WATER TREATMENT AND DISPOSAL SYSTEM, Department of Civil Engineering, University of Illinois, Urbana, Illinois, Research Report No. 14, June, 1968.

This work attempts to predict dissolved oxygen deficits in a stream with known initial conditions by taking into account the variations in deoxygenation and reaeration coefficients. A hypothetical stream situation is used to establish the significance in predicting dissolved oxygen deficit. Statistical models are formulated and tested for the variations in these coefficients using published data. Simulation techniques using the Monte Carlo method are employed in predicting the probabilistic variation in dissolved oxygen deficits for known initial conditions, and the results are verified with the survey data observed for the Ohio River-Cincinnati Pool reach. The predicted results using probabilistic model are found to agree with the observed values within practical limits and give more consistent results than conventional methods.

*OXYGEN SAG, *REAERATION, *OXYGENATION, *STATISTICAL MODELS, mathematical models, probability, biochemical oxygen demand, oxygen demand, aeration, mathematical studies, model studies, waste water treatment, waste treatment, water treatment

224. Krutilla, J. V., "THE PUBLIC INTEREST IN PRESERVING NATURAL AREAS", in THE MAINE COAST--PROSPECTS AND PERSPECTIVES, October, 1966, pp. 8-12. Center for Resource Studies, Bowdoin College, Brunswick, Maine.

There is a decreasing availability of natural resource commodities except at increasing real cost. The problem is generating interest in maintaining reserves of natural resources, whether fossil fuel or camping grounds. The public should support the maintenance of reserves, because if they do not enjoy these resources at present they will be holding the option to do so in the future. This "option demand" is an investment.

*NATURAL RESOURCES, *MAINE, *CONSERVATION, recreation, geographical regions, New England, northeast U.S., regions, resources

225. Krutilla, John V., SEQUENCE AND TIMING IN RIVER BASIN DEVELOPMENT, Resources for the Future, Inc., Washington, D.C., February, 1960.

This publication discusses the importance of treating the sequence of project development within a river basin as an element to aid in the maximizing of systems benefits. It emphasizes treatment of the river basin system as a whole, rather than a series of independent projects.

*RIVER BASINS, *TIMING, *SEQUENCE, *WATER RESOURCES DEVELOPMENT, cost-benefit analysis, economic feasibility, regions, resource development, feasibility, project benefits, benefits

226. Krutilla, John V., and Otto Eckstein, MULTIPLE-PURPOSE RIVER DEVELOPMENT STUDIES IN APPLIED ECONOMIC ANALYSIS. Johns Hopkins Press, Baltimore, Maryland.

This book is divided into two parts--the first develops a mathematical model for assessing water resource investments; the second applies the model to two actual and one proposed water resource investment. The first part discusses, at length, the issue of the interest rate that should be used in analyzing government financed investments.

*MATHEMATICAL MODELS, *INVESTMENT, *WATER RESOURCES, *MULTIPURPOSE PROJECTS, cost-benefit analysis, costs, cost analysis, mathematical studies, analysis, model studies, interest, resources, projects

227. Laborde, Alden J., PROBLEMS OF A DRILLING CONTRACTOR, Ocean Industry, Vol. 2, No. 4, April, 1967, pp. 22-25.

The author discusses various problems and costs associated with oil rig operations. He gives a breakdown of certain operating costs: insurance, interest, etc.

*OFFSHORE PLATFORMS, *OIL WELLS, *OPERATING COSTS, *DRILLING, oil industry, oil fields, industries, engineering structures, hydraulic structures, structures

228. Lackey, James B., "NUTRIENT AND POLLUTANT RESPONSE OF ESTUARINE BIOTAS", in PROCEEDINGS OF THE NATIONAL SUMPOSIUM ON ESTUARINE POLLUTION, August 23-25, pp. 188-217. Department of Civil Engineering, Stanford University, Stanford, California.

The behavior of microbiota--algae and protozoa--as affected by commercial, recreational, and metropolitan uses of estuarine waters are outlined. Some of the findings presented at the symposium are as follows:

1. Estuaries and bays are of great economic and recreational value, for nurseries, fishing grounds, shellfisheries, crustacean production, boating, and bathing.
2. Human activity often modifies their preferred ecology by adding nutrients or pollutants.
3. The suspended (plankton) microscopic plants and animals, and those of the interface (benthos) are most easily studied qualitatively and quantitatively.
4. Some pollutants, such as silt, sharply reduce the microscopic populations.
5. The role of the engineer with regard to estuarine studies is that of seeing that adequate biological studies are made, so that he in turn can design and construct the necessary treatment plants and outfalls which will prevent overenrichment or pollution.

*NUTRIENTS, *MARINE MICROORGANISMS, *POLLUTANTS, recreation, water sports, environment, aquatic environment, estuarine environment, water quality, sewage bacteria, environmental effects, aquatic life, aquatic microorganisms, microorganisms, seston, invertebrates, shellfish, waste disposal, sewage disposal, water chemistry, ecology, water pollution, water pollution control, control, algae, plants, commercial fishing, fishing, industries, commercial shellfishing, animals, aquatic animals

229. Lager, John A., and George Tchobanoglous, "USE OF HYDRAULIC AND MATHEMATICAL MODELS FOR DETERMINING EFFLUENT DIFFUSION IN SOUTH SAN FRANCISCO BAY", in PROCEEDINGS OF THE NATIONAL SYMPOSIUM ON ESTUARINE POLLUTION, August 23-25, 1967, pp. 384-422. Department of Civil Engineering, Stanford University, Stanford, California.

Studies are reported summarizing the use of a physical hydraulic model and a mathematical model for assessing the waste assimilative capacity of San Francisco Bay. Specific effects studied include initial mixing and dilution, waste dispersion, and decay of waste material in the estuary. The model studies were directed toward assessment of dissolved oxygen and BOD. It was concluded that the mathematical model yielded more reliable results than did the hydraulic model.

*CALIFORNIA, *MATHEMATICAL MODELS, *WASTE ASSIMILATIVE CAPACITY, *HYDRAULIC MODELS, *MATHEMATICAL STUDIES, *MODEL STUDIES, *WASTE DILUTION, southwest U.S., Pacific coast region, regions, geographical regions, biochemical oxygen demand, dissolved oxygen, oxygen demand, bodies of water, bays, diffusion, effluents, mixing, waste disposal, dispersion, degradation (decomposition), water pollution

230. Lamb, James C., III, ECONOMIC ASPECTS OF SALINE-WATER CONVERSION, American Water Works Association, Journal, Vol. 54, No. 7, July, 1962, pp. 781-788.

The purpose of this paper is to review the basis for costs which have been presented for both conventionally treated and desalted water supplies and to discuss several factors which must be considered in any definite comparison of these costs.

Among the points noted by the author are the following:

1. Cost of desalting by distillation is not greatly affected by concentration of salts. On the other hand, electrodialysis and several other processes are affected by concentration. These processes seem particularly suited to desalting brackish waters.

2. The only practical way of comparing desalination costs to the costs of other fresh water sources is on the basis of the cost on an additional increment of fresh water added at a specific location, both estimates to include all times of expense.

3. Desalting may play an important role on a local level, but it is not anticipated that saline-water conversion will supplement national water resources to a significant degree in the foreseeable future.

*DESALINATION, *ECONOMIC FEASIBILITY, *DISTILLATION, *ELECTRODIALYSIS, *BRACKISH WATER, costs, feasibility, demineralization, separation techniques, water purification, water treatment, dialysis, membrane processes, saline water, water types

231. Langbein, W. B., and W. G. Hoyt, WATER FACTS FOR THE NATION'S FUTURE, 1959. The Ronald Press, New York.

This book focuses on fresh water data-collection programs in the United States and discusses the uses of these data in relation to the Nation's water problems. Estuary considerations are not specifically treated.

*DATA COLLECTION, *STATISTICS, hydrological data, fresh water, United States, geographical regions, regions

232. Lauff, George H., editor, ESTUARIES, Publication No. 83, 1967. American Association for the Advancement of Science, Washington, D.C.

This is a collection of 71 papers presented at an estuarine converence. Most of the articles deal with physical and biological, rather than economic, aspects of estuaries. Two articles deal with the problem of defining estuaries. Sundry articles relate to salinity, circulation, sedimentation, geomorphology, microbiota, nutrients, ecology, and physiology. Several articles deal with estuarine fisheries, including those of the Gulf Coast of the United States, West Africa, Indian Ocean Coastal Zone, and Europe. The article by J. L. McMugh, entitled "Estuarine Nekton", provides excellent perspective on the general topic, and is abstracted elsewhere in this bibliography. Four articles related to estuarine pollution, including "The Role of Man in Estuarine Processes" by L. Eugene Cronin, which provides good general perspective on past and present human influences on physical and biological processes in estuaries. The book contains an extensive supplemental bibliography with references through 1966.

*WATER POLLUTION, *WATER PROPERTIES, *ESTUARINE FISHERIES, *FOREIGN WATERS, *NEKTON, *BIBLIOGRAPHIES, sedimentation, nutrients, geomorphology, ecology, fisheries, United States, geographical regions, regions, Indian Ocean, bodies of water, oceans, surface waters, coasts, salinity, chemical properties, water types, animals, aquatic animals, aquatic life, seston

233. Leffel, R. Ernest, "ESTUARINE POLLUTION OF THE CHAO PHRAYA RIVER AT BANGKOK, THAILAND", in PROCEEDINGS OF THE NATIONAL SYMPOSIUM ON ESTUARINE POLLUTION, August 23-25, 1967, pp. 370-383. Department of Civil Engineering, Stanford University, Stanford, California.

Sources of pollution in the Chao Phraya River at Bangkok, Thailand, are outlined. A mathematical model is presented for calculating dissolved oxygen relationships in the estuary. It is stated that pollution conditions in the Chao Phraya estuary do not conform to assumptions employed in the development of previous formulations of oxygen sag relationships.

*WASTE ASSIMILATIVE CAPACITY, *DISSOLVED OXYGEN, *MATHEMATICAL MODELS, *WATER POLLUTION, *FOREIGN COUNTRIES, oxygen sag, mathematical studies, model studies, rivers, bodies of water, running waters, streams, surface waters

234. Lefler, Hugh Talmage, and Albert Ray Newsome, NORTH CAROLINA, THE HISTORY OF A SOUTHERN STATE, 1954. University of North Carolina Press, Chapel Hill, North Carolina.

This study is concerned with why the coastal area of North Carolina did not develop in the same manner as such regions as Massachusetts and New Jersey. The author gives three major reasons:

1. The treacherous coast and lack of good ports were major factors in diverting English colonization to the Chesapeake region after the failure of the Raleigh colonies at Roanoke Island. When permanent settlement of North Carolina began almost a century later, the absence of good harbors retarded colonization direct from Europe, and consequently the colony was settled largely "as an overflow from other colonies". These same geographic factors operated throughout the nineteenth century.

2. The prevailing regime of isolation and self-sufficiency bred inertia, provincialism, conservatism, individualism, ignorance, and prejudice as characteristics of the people.

3. Economic dependence upon neighboring states, particularly Virginia, induced intellectual and political dependence.

Hence the author concludes, "No phase of life escaped the paralyzing effect of nature's curse on poor transportation."

*TRANSPORTATION, *COMMUNITY DEVELOPMENT, *HISTORY, *NORTH CAROLINA, navigation, economic life, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, regions, southeast U.S., harbors, coast

235. Lehmann, Richard A., THE PRINCIPLES OF WATERFRONT RENEWAL: A SUMMARY OF EXPERIENCE IN FIFTY AMERICAN CITIES, Landscape Architecture, Vol. 56, No. 4, July, 1966, pp. 286-291.

The conclusion reached in this summary is that good waterfront renewal projects should contain these aesthetic goals: (1) physical access, (2) visual access, (3) historic preservation, and (4) site identity.

*CITY PLANNING, *AESTHETICS, *SHORES, *HARBORS, landscaping, planning

236. Leighton, D., I. Nusbaum, and S. Mulford, EFFECTS OF WASTE DISCHARGE FROM POINT LOMA SALINE WATER CONVERSION PLANT ON INTERTIDAL MARINE LIFE, Water Pollution Control Federation, Journal, Vol. 39, No. 7, July, 1967, pp. 1190-1202.

The effects of thermal and brine discharges from the Point Loma, California, desalting plant are described. After a few months of operation, it became evident that the effluents were having a deleterious effect on at least some of the organisms, both plant and animal, which inhabit the intertidal zone. The effects were restricted to the area covered by the effluent streams and under low tide conditions. The authors conclude that the experience at Point Loma provides a clear warning that waste discharge problems would have to be resolved before there could be serious contemplation of considerably larger distillation plants.

*WATER POLLUTION EFFECTS, *DESALINATION, *CALIFORNIA, *WASTE DISPOSAL, *INTERTIDAL AREAS, *AQUATIC LIFE, regions, demineralization, separation techniques, water purification, water treatment, geographical regions, Pacific coast region, southwest U.S., thermal pollution, water pollution, brines, saline water, water types

237. Levine, Max, Henry Minette, and Ralph H. Tanimoto, "CHARACTERISTICS AND EXPEDITIOUS DETECTION OF BACTERIAL INDICES OF POLLUTION OF MARINE BATHING BEACHES", in PROCEEDINGS OF THE FIRST INTERNATIONAL CONFERENCE ON WASTE DISPOSAL IN THE MARINE ENVIRONMENT, July 22-25, 1959, pp. 11-28. Pergamon Press, New York.

The coliform index, as presently employed, does not appear to be a realistic measure of the hazard from enteric disease nor the aesthetic qualities of saline bathing beaches. Indicator organisms more strictly characteristic of the intestinal flora of man and animals, such as Streptococcus faecalis and E. coli, are considered to be more reliable measures of sewage pollution of marine bathing waters.

The E. coli index, or the ratio of the E. coli to the coliform index, probably constitutes the most practicable criterion of sewage pollution of marine bathing beaches at this time.

The membrane filter technique, employing BALB, ECM, Endo, and MacConkey broths at appropriate concentrations and temperatures, should be studied as a means for determining the E. coli index.

*MEASUREMENT, *COLIFORMS, *PUBLIC HEALTH, *BEACHES, *POLLUTANT IDENTIFICATION, *SEWAGE BACTERIA, swimming, recreation facilities, recreation, water pollution sources, water pollution effects, water sports, municipal wastes, surface waters, bodies of water, bacteria, microorganisms, plants, E.coli, pathogenic bacteria, streptococcus, aerobic bacteria, enteric bacteria, oceans

238. Liebman, Jon C., and David H. Marks, "A 'BALAS' ALGORITHM FOR ZONED UNIFORM TREATMENT", in PROCEEDINGS OF THE NATIONAL SYMPOSIUM ON ESTUARINE POLLUTION, August 23-25, 1967, pp. 44-59. Department of Civil Engineering, Stanford University, Stanford, California.

The problem of finding appropriate treatment levels for waste discharges located along an estuary on which quality standards are imposed is complex. The uniform treatment method is expensive and inequitable. A cost-minimization model (a mathematical model of the physical characteristics of the water body employed) is efficient, but inequitable. For example, industrial plants A and B located next door to each other have similar products and wastes, but the cost-minimization solution may require A to treat while B does nothing, because the unit cost of treatment is lower at A due to more efficient operation. Thus, A bears the entire brunt of being more efficient while B pays nothing.

A zoned solution is proposed wherein waste producers are divided into categories, and treatment levels are found which minimize the cost-subject to the requirement that all members of the category provide the same treatment. A branch-and-bound algorithm is developed to obtain the solution.

*MATHEMATICAL MODELS, *WATER POLLUTION TREATMENT, *WASTE DISPOSAL, *WASTE TREATMENT, *COST SHARING, zoning, regulation, mathematical studies, model studies

239. Livingstone, Robert, Jr., A PRELIMINARY BIBLIOGRAPHY WITH KWIC INDEX ON THE ECOLOGY OF ESTUARIES AND COASTAL AREAS OF THE EASTERN UNITED STATES, Department of the Interior, Fish and Wildlife Service, Washington, D.C., May, 1965.

This bibliography, which contains more than 5,470 references, is an initial effort to bring together references on the ecology of estuaries and coastal water of the eastern United States, and stresses the period 1900-60. It is the starting point for the compilation of a more comprehensive list of the future.

The bibliography is in two parts: (1) the complete entries listed alphabetically by authors and (2) a KWIC index (keyword-in-context) to significant words relevant to title and context.

*BIBLIOGRAPHIES, *ECOLOGY, *DOCUMENTATION, *COASTS, environment, southeast U.S., northeast U.S.

240. Lockett, John B., "PHENOMENA AFFECTING IMPROVEMENT OF THE LOWER COLUMBIA ESTUARY AND ENTRANCE", in PROCEEDINGS OF THE INTER-AGENCY SEDIMENTATION CONFERENCE, 1963, Miscellaneous Publication No. 970, June, 1965, pp. 626-668. Department of Agriculture, Washington, D.C.

This article gives an historical account of efforts to maintain a channel through the Columbia River entrance. Jetties were used with some success to confine entrance flows to alter sediment disposition. These jetties have been rebuilt and some dredging has been required. Disposal was off-shore.

The article reviews more recent scientific analysis which has been conducted on sediment movement and estuarine hydraulics.

*CHANNEL IMPROVEMENT, *OREGON, *COLUMBIA RIVER, *JETTIES, dredging, bodies of water, interstate rivers, rivers, running waters, streams, surface waters, sediment distribution, sediment control, dikes, earthworks, embankments, engineering structures, hydraulic structures, structures, coastal structures, sediment transport, sedimentation

241. Loucks, D. P., C. S. Revelle, and W. R. Lynn, LINEAR PROGRAMMING MODELS FOR WATER POLLUTION CONTROL, Institute of Management Science, Journal, Vol. 14, No. 4, December, 1967, pp. B166-B181.

Two linear programming models are presented for determining the amount of waste water treatment required to achieve at minimum cost any particular set of stream dissolved oxygen standards within a river basin. Derived from the generalized Streeter-Phelps differential equations used to describe the rates of dissolved oxygen depletion and recovery of streams, these models are adaptable to any river basin configuration. They can be used not only in determining system costs for various quality standards but also for measuring the cost sensitivity to changes in the design stream and wastewater flows and treatment facility location. An example illustrates the use of these models.

*MATHEMATICAL MODELS, *LINEAR PROGRAMMING, *WASTE WATER TREATMENT, *DISSOLVED OXYGEN, *RIVER BASINS, *COSTS, cost-benefit analysis, waste treatment, water treatment, optimization, mathematical studies, model studies, regions, water pollution control, control

242. Ludwig, Harvey F., and Ben Onedera, SCIENTIFIC PARAMETERS OF MARINE WASTE DISCHARGE, International Journal of Air and Water Pollution, Vol. 7, No. 2/3, May, 1963, pp. 159-172.

The article presents a discussion of a study undertaken by Engineering-Science, Inc., on behalf of the California State Water Pollution Control Board, for the "assembly, collation, and critical review of the sizeable mass of marine monitoring data accumulated over the past decade, both for 'open' coastal waters and for 'restricted' waters such as estuaries and bays". It presents conclusions on the meaningfulness and usefulness of specific types of measurements employed, the effects of monitoring program findings on design of treatment facilities, and the significance of information voids.

*WATER POLLUTION, *ECOLOGY, *DATA COLLECTIONS, *TREATMENT FACILITIES, monitoring, aquatic productivity, plant growth, nutrients, productivity, water treatment

243. Maass, Arthur, BENEFIT-COST ANALYSIS: ITS RELEVANCE TO PUBLIC INVESTMENT DECISIONS, Quarterly Journal of Economics, Vol. LXXX, No. 2, May, 1966, pp. 208-226.

The author states that "the major limitation of benefit-cost analysis, as it has been applied in the United States, is that it ranks projects and programs in terms of economic efficiency". He maintains that economic efficiency is not the only goal of public programs, and that the other goals, such as income redistribution, should be explicitly recognized and integrated into formal project analysis. The author states that trade-offs among the relevant benefit variables must be sought and suggests that establishment of such trade-offs is possible.

*COST-BENEFIT ANALYSIS, *PUBLIC BENEFITS, *INVESTMENT, social values, feasibility studies, feasibility, economic efficiency, value, social impact, social aspects, benefits

244. Mac Kichon, K. A., and J. C. Kammerer, ESTIMATED USE OF WATER IN THE UNITED STATES, 1960, Geological Survey Circular 456, Washington, D.C., 1961.

This document provides analysis of water use data originating from several sources. Tables provide estimates of saline water used by the electric power industry. Another provides data by water resources region, e.g., Chesapeake, Ohio, etc. The report states that the use of saline water was doubled between 1955 and 1960.

*WATER UTILIZATION, *ELECTRIC POWER INDUSTRY, *SALINE WATER, *STATISTICS, geographical regions, efficiencies, regions, industries, water types, data collections

245. Mackin, J. G., and S. H. Hopkins, STUDIES ON OYSTER MORTALITY IN RELATION TO NATURAL ENVIRONMENTS AND TO OIL FIELDS IN LOUISIANA, Institute of Marine Science, Publications, Vol. 7, July, 1962, pp. 1-131.

Field studies showed that oysters had a consistently high mortality rate throughout the warmer half of the year in the study area, and that mortality rate increased with salinity increase within this area.

Within oil fields, the amounts of unsaponifiable carbon tetrachloride extractives were highest (up to 5.8 percent) in mud samples taken near bleed-water outlets and other known centers of pollution, and were correlated with high (up to 0.00578 percent) "pentane and heavier hydrocarbons" as measured independently by a commercial laboratory. "Hydrocarbon" content of mud and water was no higher in areas of high oyster mortality than in areas of low mortality. Bacteriological studies showed that crude oil and its fractions were rapidly destroyed by bacteria living in Louisiana bay muds.

It was concluded that oil production factors of the kinds tested could not be responsible for the oyster mortalities spread throughout the large area where damage was claimed.

*OYSTERS, *OIL WASTES, *MORTALITY, southeast U.S., regions, Gulf coastal plain, animals, benthos, aquatic animals, aquatic life, benthic fauna, commercial shellfish, invertebrates, marine animals, mollusks, shellfish, geographical regions, coastal plains, Louisiana, organic matter, wastes, oil industry, industries, water pollution, salinity, chemical properties, water properties, water temperature, temperature

246. Maehler, Claude Z., and Arnold E. Greenberg, "IDENTIFICATION OF PETROLEUM PRODUCTS IN ESTUARINE WATERS", in PROCEEDINGS OF THE NATIONAL SYMPOSIUM ON ESTUARINE POLLUTION, August 23-25, 1967, pp. 517-536. Department of Civil Engineering, Stanford University, Stanford, California.

The increased concern about spills of petroleum products in the estuarine environment has brought about increased demands for analytical methods of identifying pollutants and their sources. A number of qualitative comparative procedures have been described which establish the clear recognition of petroleum products in water. These procedures are capable of demonstrating characteristics of petroleum materials peculiar to individual lots, but analysis should generally include several of the techniques. They are therefore useful in comparing oil spills with reference samples.

A simple sequential scheme is presented which includes gas chromatographic analysis of vapor space gas and solvent extraction followed by infrared spectrophotometric and paper chromatographic examinations.

*OIL WASTES, *POLLUTANT IDENTIFICATION, *ANALYTICAL TECHNIQUES, *GAS CHROMATOGRAPHY, *SPECTROPHOTOMETRY, *WATER ANALYSIS, wastes identification, organic matter, wastes, estuarine environment, aquatic environment, environments, water quality, analysis, gases, water pollution control, control, water pollution sources, chromatography, photometry, water vapor

247. MAN AND THE ESTUARY, Conservation Foundation Letter, April 22, 1968, pp. 8-11.

The economic benefits and uses of the estuary are listed. The article maintains that the benefits of estuaries are fairly easy to measure, but the economic losses from abuses of this resource are harder to assess. Some data on economic losses from dredging, filling, and pollution of estuaries are given.

*COSTS, *BENEFITS, *ECONOMIC EFFICIENCY, water pollution effects, dredging

248. Manning, J. H., THE MARYLAND SOFT SHELL CLAM INDUSTRY AND ITS EFFECTS ON TIDEWATER RESOURCES, Maryland Department of Research and Education, Chesapeake Biological Laboratory, Solomons, Maryland, Report No. 11, January, 1957.

This report is a summary of information on the effects of hydraulic dredging on the soft shell clam industry in Maryland. Although operational costs of the dredge are high, its use made soft shell clams a million dollar resource from 1952 when dredging was first allowed to 1957 when the report was written.

*CLAMS, *MARYLAND, *NATURAL RESOURCES, *COMMERCIAL FISHING, *DREDGING, economic impact, mollusks, invertebrates, commercial shellfish, benthos, benthic fauna, aquatic life, aquatic animals, animals, fishing, industries, resources, operating costs, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U.S., regions

249. Manning, J. H., A SUMMARY REPORT ON MARYLAND'S COMMERCIAL FISHERIES, 1957-1966, Department of Chesapeake Bay Affairs, Annapolis, Maryland, 1967.

This document reports the values of Maryland's commercial fisheries from 1957 through 1966. The landed value of Maryland's commercial fisheries products reached an all-time high of $14,012,000 in 1966, with oysters accounting for 56 percent.

The value of Maryland's manufactured fisheries products reached $39,000,000 in 1966.

Data are provided on the number of people employed in the fisheries industry.

Maryland now leads the U.S. in oyster production and can be expected to do so for several years.

*COMMERCIAL FISHING, *COMMERCIAL SHELLFISH, *FISH HARVEST, *MARKET VALUE, *MARYLAND, oysters, animals, aquatic animals, aquatic life, invertebrates, shellfish, benthic fauna, benthos, marine animals, mollusks, value, income, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U.S., regions, employment

250. Mansueti, R. J., EFFECTS OF CIVILIZATION ON STRIPED BASS AND OTHER ESTUARINE BIOTA IN CHESAPEAKE BAY AND TRIBUTARIES, Gulf and Caribbean Fisheries Institute, Proceedings, Vol. 14, 1962.

The author states that the effects of civilization, some harmful, some wasteful, have not materially reduced the potential productivity of the Chesapeake estuary. The hypothesis is advanced that civilization and striped bass are compatible in that increasing fertilization by man may be directly responsible for the unusual increase in number and magnitude of dominant year classes. The problem of excessive and uncontrolled mineral fertilization in estuaries is discussed in relation to striped bass and other biota.

*STRIPED BASS, *AQUATIC PRODUCTIVITY, *FERTILIZER, *MARYLAND, marine fish, estuarine environment, environmental effects, productivity, sport fisheries, nutrient requirements, fisheries, Atlantic coastal plain, Appalachian Mountain region, animals, aquatic animals, aquatic life, fish, marine animals, saline water fish, sea basses, wildlife, agricultural chemicals, bay, regions, northeast U.S., geographical regions, coastal regions

251. Mansueti, R. J., and E. H. Hollis, STRIPED BASS IN MARYLAND TIDEWATER, National Resources Institute, University of Maryland, Solomons, Maryland, Educational Series No. 61, February, 1963.

A summary of research conducted on the striped bass in Maryland over a ten-year period from 1953 to 1963 is presented. While most of the material concerns the biology of the fish, the most important and valuable fish in Maryland, information on commercial landings from 1887 through 1962 is provided.

Beginning in 1959, annual commercial catches of striped bass became very high, averaging about 4,000,000 pounds per year. The retain values were as high as $900,000 annually at the peak of production.

Economic surveys of the sport fishery in Maryland indicate variable expenditures and investments. The Potomac survey showed the daily cost per fisherman to range from $1.50 per day to $35.00 per day in the large cruiser-type fishing boats.

A discussion of present-day conservation and management methods as well as suggestions for future management and improvement of the fishery are given.

*MARYLAND, *STRIPED BASS, *COSTS, *FISH CONSERVATION, sport fishing, commercial fishing, fishing, Atlantic coastal plain, Appalachian Mountain region, coastal plains, geographical regions, northeast U.S., regions, animals, aquatic animals, aquatic life, fish, marine animals, marine fish, saline water fish, sea basses, wildlife, animal physiology, competition, conservation, surveys, statistics, data collections

252. Margolis, Julius, SECONDARY EFFECTS, EXTERNAL ECONOMICS, AND THE JUSTIFICATION OF PUBLIC INVESTMENT, The Review of Economics and Statistics, Vol. 39, No. 3, August, 1957, pp. 284-291.

This article discusses secondary benefits and external economies in relation to Bureau of Reclamation policies and programs.

*COST-BENEFIT ANALYSIS, *INDIRECT BENEFITS, *FEDERAL GOVERNMENT, costs, benefits, governments

253. MARINE, ESTUARIAN, AND RIPARIAN POLLUTION DISASTERS AND THEIR CONSEQUENCES, Ocean Science and Technology Advisory Committee, Ocean Resources Subcommittee Meeting, December 12-13, 1967. National Security Industrial Association, Washington, D.C.

This meeting, which covered water pollution disasters, was held in three parts:
Part I. Description of disaster and consequences.
Part II. Technical capabilities for countermeasure.
Part III. Contingency program for prevention and response.
Papers with examples and suggestions were given within each category.

*WATER POLLUTION, *DISASTERS, *WATER POLLUTION TREATMENT, water treatment

254. MARINE RESOURCES AND ENGINEERING DEVELOPMENT ACT OF 1966, House of Representatives, 89th Congress, 2nd Session, Report No. 1548, May 24, 1966.

This act defines the limits and guidelines for the exploitation of marine resources.

*LEGAL ASPECTS, *WATER RESOURCES, resources, legislation

255. MARINE SCIENCE AFFAIRS...A YEAR OF TRANSITION, Report of the President to the Congress on Marine Resources and Engineering Development, February, 1967.

This document is the initial report by the Marine Sciences Council to the President and puts forth steps taken to meet the objectives of the Marine Resources and Engineering Development Act of 1966.

A brief section, "Man's Uses of the Shoreline", discusses estuary problems and refers to the planned scale model of the Chesapeake Bay to be built by the Corps of Engineers.

*LEGISLATION, *FEDERAL GOVERNMENT, legal aspects, water resources, resources, bays, bodies of water, coasts, governments

256. MARITIME AGENCY STATUS, CHANNEL PROBLEMS CREATED BY HUGE SHIPS CONCERNS OF AAPA, Traffic World, Vol. 131, No. 14, September 30, 1967, pp. 25-29, 100-105.

This report on the annual convention of the American Association of Port Authorities covers three economic issues: (1) the advantages of specialized ports, (2) the limitations to harbor and channel deepening, and (3) the importance of efficient use of land loading and transportation facilities.

*CHANNEL IMPROVEMENT, *HARBORS, *SHIPS, transportation

257. Markowski, S., OBSERVATIONS ON THE RESPONSE OF SOME BENTHONIC ORGANISM TO POWER STATION COOLING, Journal of Animal Ecology, Vol. 29, No. 2, 1960, pp. 349-357.

The author reports observations made on the settling of benthonic organisms on experimental slabs placed in the intake and in the outfall water of the power station located at the Cavendish Dock. Data indicate that outfall area is more conducive to growth as the benthonic forms appear earlier than in the intake. No algae growth was found in the intake, but there was very prolific growth in the outfall. Specific composition of benthonic invertebrates were similar in both intake and outfall slabs. In addition, denser animal populations were found in the intake than in the outfall. General characteristics of the environments and the factors introduced by the power station into the aquatic medium are discussed.

*POWERPLANTS, *THERMAL POLLUTION, *TEMPERATURE, *COOLING WATER, chemical properties, ecology, salinity, benthos, aquatic life, algae, plants, water properties, water temperature, outlets, hydroelectric plants, electric powerplants, engineering structures, industrial plants, structures, afterbays, water types, intakes

258. Marshall, A. R., PRACTICES AFFECTING SOUTH ATLANTIC AND GULF COAST MARSHES AND ESTUARIES - DREDGING AND FILLING, U.S. Bureau of Sport Fisheries, Vero Beach, California, 1967.

Direct and indirect effects of dredging and filling on the fish and wildlife resources of Florida's estuarine and freshwater habitats are discussed.

Aspects of the problem discussed include: direct destruction of swamp, marsh, and bay bottom habitat in the immediate project area; destruction of spawning and nursery habitat by siltation; reduction of light penetration; creation of anaerobic bottom conditions; reduction of nutrient outflow from marshes and swamps.

Specific examples are cited for Boca Ciega Bay, Tampa Bay, Biscayne Bay, Indian River, and St. John's River.

*MARSHES, *LANDFILLS, *DREDGING, *AQUATIC HABITATS, *FLORIDA, *FISH, silts, habitats, environment, food chains, food habits, breeding, spawning, natural resources, wetlands, conservation, wildlife, animals, wildlife conservation, bays, bodies of water, bayous, Atlantic coastal plain, coastal plains, geographical regions, Gulf coastal plains, regions, southeast U.S., animal behavior, behavior, resources

259. Marts, M. E., and W. R. D. Sewell, THE CONFLICT BETWEEN FISH AND POWER RESOURCES IN THE PACIFIC NORTHWEST, Association of American Geographers, Annals, Vol. 50, No. 1, March, 1960, pp. 42-50.

This article discusses the relative economic values of fishing and electric power industries and the difficulties inherent in attempting to resolve the conflict. Foremost among the factors which tend to perpetuate the problem are (1) the historic importance of the fishing industry in the Pacific Northwest, (2) inappropriate comparisons of values of fish and power, (3) increasing costs for preserving the fisheries, and (4) the time required to study the biological aspects of the problem.

Compromise alternatives to the mutual use of the water resource are given. These include (1) fishing regulation, (2) sanctuary stream programs, (3) the development of runs on non-power streams, and (4) the development of alternative fisheries and the provision of alternative occupations for fishermen.

*ELECTRIC POWER, *COMMERCIAL FISHING, *PACIFIC NORTHWEST U.S., *COMPETING USES, *VALUE, appraisals, hydroelectric plants, regulation, employment opportunities, geographical regions, regions, fisheries, costs, efficiencies, water utilization, fish conservation, conservation, wildlife conservation, fishing, industries, electric powerplants, engineering structures, industrial plants, powerplants, structures, afterbays

260. MARYLAND: A GUIDE TO THE OLD LINE STATE, 1940. Oxford University Press, New York.

This is a comprehensive guide to the state of Maryland which focuses on Chesapeake Bay and its effect on the development of the economic and social life of the State from the earliest settlement to the era immediately preceding World War II.

*HISTORY, *MARYLAND, *SOCIAL IMPACT, *VIRGINIA, *ECONOMIC IMPACT, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U.S., regions, southeast U.S., social aspects, bays, bodies of water

261. MARYLAND, ITS RESOURCES, INDUSTRIES, AND INSTITUTIONS, 1893. Johns Hopkins Press, Baltimore, Maryland.

This late nineteenth-century compilation provides an inventory of the resources, industries, and institutions of the Maryland of 1890. Some historical background is included in the description of these institutions and economic activities.

*HISTORY, *MARYLAND, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U.S., regions

262. Massmann, William H., THE FISHERIES--A NEGLECTED ASPECT OF ESTUARINE RESEARCH, 29th North American Wildlife and Natural Resources Conference, Transactions, March 9-10, 1964, pp. 337-352.

The author states that the bulk of marine sport fish of the Atlantic and Gulf coasts are dependent on estuaries for either spawning, nursery, or feeding grounds, but there has been little research on the management of estuarine fishes.

Striped bass and Atlantic shad research has uncovered basic information, but most questions regarding management remained unanswered. Further detailed life history, ecological and behavior studies, information on fish population dynamics are needed for important estuarine dependent coastal fishes (flounders, weakfish, spotted seatrout, and others). Information is also needed on effects of environmental factors and engineering structures on fish populations. Basic studies on the fishes in estuaries should ultimately result in methods for minimizing or compensating for damage to these waters. The use of artificial reefs by sport fishes needs to be clearly evaluated. Catch regulations, where needed, should be based on the results of biological studies, and their effects should be thoroughly evaluated.

*SPORT FISH, *FISH MANAGEMENT, *ENVIRONMENTAL EFFECTS, *ESTUARINE FISHERIES, life history studies, management, fisheries, fish hatcheries, ecology, animals, aquatic animals, aquatic life, fish, wildlife

263. Maton, Gilbert L., E. R. Christie, and M. J. Tenzer, A PERSPECTIVE OF REGIONAL AND STATE MARINE ENVIRONMENTAL ACTIVITIES, A QUESTIONNAIRE SURVEY, STATISTICS AND OBSERVATIONS, John I. Thompson and Company, Washington, D.C., for Institute of Public Administration, PB 177765, February 29, 1968.

This report contains a summary of data derived from questionnaires sent by the authors to qualified representatives of each of the states and territories of the Unites States bordering on the coasts or Great Lakes. The purpose of the report was to present information concerning the organization and function of state, local, and regional governmental agencies involved in marine environmental activities. These activities were classified into six functional areas: (1) recreation, (2) commercial fishing and living resources, (3) waste disposal, (4) non-living resources, (5) maritime commerce, and (6) conservation.

Observations: The state executive structure for marine environment activities is a diffuse policy and planning network loosely connected but with enough interaction among the cognizant agencies to permit the essential and critical programs to happen. State governments understand the significance of the marine environment and are making good policy decisions, but they take too long to do so. The states fear federal intervention in areas which have traditionally been in state control, such as sports, commercial fishing, pollution, and conservation. A bibliography associated with this study is cited elsewhere in this compilation (Report No. PB 177764).

*FISH CONSERVATION, *WATER POLLUTION, *FEDERAL-STATE WATER RIGHTS CONFLICTS, *FEDERAL JURISDICTION, *STATE JURISDICTION, structures, hydraulic structures, engineering structures, water treatment, water purification, separation techniques, harbors, marinas, breakwaters, shore protection, marine animals, marine fish, marine fisheries, commercial fishing, sport fishing, commercial shellfish, saline water fish, wildlife, conservation, wildlife conservation, aquatic plants, plants, demineralization, shellfish, invertebrates, industries, fishing, marine plants, recreation, desalination, industrial wastes, wastes, recreation facilities, fisheries, animals, aquatic animals, aquatic life, fish, water sports

264. McCabe, J. S., ORGANIC POLLUTION OF NEW YORK HARBOR APPLICATION, Water Pollution Control Federation, Journal, Vol. 34, No. 10, 1962, pp. 987-998.

The relation between pollution and dissolved oxygen in the New York Harbor is reviewed. Field sampling programs and analytical studies are included in the review. Reference is made to a study conducted in 1960 which developed a mathematical model for predicting the dissolved oxygen profile from the city line on the Hudson River to the Narrows.

*WATER POLLUTION, *DISSOLVED OXYGEN, *HARBORS, *NEW YORK, *SAMPLING, *ANALYTICAL TECHNIQUES, mathematical models, mathematical studies, model studies, Appalachian Mountain region, geographical regions, Great Lakes region, northeast U.S., forecasting, regions, Hudson River, bodies of water, rivers, running waters, streams, surface waters, on-site investigations

265. McCallum, Gordon E., "WATER QUALITY IN THE POTOMAC ESTUARY", in PROBLEMS OF THE POTOMAC ESTUARY, January, 1964, pp. 5-10. Interstate Commission on the Potomac River Basin, Washington, D.C.

This is a short general discussion of past uses and goals of pollution control in the Potomac Estuary. Implications of population growth for future investment requirements for pollution control in the Washington, D.C. area are discussed. Population projections for 1985 and 2010 are given. The implied biochemical oxygen demand loading resulting after 90 percent BOD reduction in 1985 by treatment plants is estimated.

*WATER POLLUTION CONTROL, *FORECASTING, *BIOCHEMICAL OXYGEN DEMAND, *HUMAN POPULATION, *DISTRICT OF COLUMBIA, *GROWTH RATES, Virginia, Maryland, population, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U.S., regions, southeast U.S., oxygen demand, cities, water quality, rates

266. McCarty, James C., and Howard S. Harris, "THE FUTURE OF AN ESTUARY", in PROCEEDINGS OF THE NATIONAL SYMPOSIUM ON ESTUARINE POLLUTION, August 23-25, 1967, pp. 335-369. Department of Civil Engineering, Stanford University, Stanford, California.

This paper discusses existing and future water quality in San Francisco Bay and outlines means to cope with pollution's adverse effects on beneficial uses of the Bay water. A mathematical model is employed to predict future water quality in terms of total nitrogen and total dissolved solids. Current nitrogen levels of 2 mg/liter are expected to rise to 7 mg/liter by 1990. Four means of controlling future water quality are defined: (1) control of water at the source, (2) collection and treatment of water, (3) conveyance of wastes, and (4) regulation of streamflow. It is concluded that a major obstacle to the implementation of any control program will be coordinating the diverse interests of the many agencies concerned with water quality in San Francisco Bay.

*WATER QUALITY, *NITROGEN, *DISSOLVED SOLIDS, *MATHEMATICAL MODELS, *WATER QUALITY CONTROL, *CALIFORNIA, southwest U. S., regions, control, quality control, gases, Pacific coast region, geographical regions, water control, mathematical studies, model studies, beneficial use, streamflow, channel flow, flow, waste treatment, water treatment

267. McCrone, A. W., THE HUDSON RIVER ESTUARY: HYDROLOGY, SEDIMENTS AND POLLUTION, The Geographical Review, Vol. 56, No. 2, 1966, pp. 175-189.

A study was conducted of a 70-mile section of the Hudson River estuary from Kingston to Dobbs Ferry. The broad purpose was to observe hydrology and pollution and to obtain and analyze samples of river-bottom sediments from the Hudson estuary for radiological and associated geological and biological studies. The purpose was to identify the radioactive pollutants in the river and to determine the effects of their accumulation in the bottom muds and in organisms such as fish.

Twenty-six sampling stations yielded 180 samples during the summer of 1964. Additional samples were taken from a severely polluted part of the river near Mechanicsville and from the Mohawk River near Crescent. Samples were taken of surface water, bottom water, and bottom mud. Readings were taken of salinity, temperature, and pH. Fathograms were recorded at key river cross sections. Bottom sediments were dried and analyzed for particle size and oxidizable organic matter. Minerals were identified microscopically, and cation exchange capacities and other chemical properties were determined. Radiation counts were made on sections taken of bottom core-samples. It was concluded that radioactivity concentrated in the Hudson River fish is insignificant in so far as public health is concerned.

*POLLUTANT IDENTIFICATION, *SEDIMENTS, *RADIOACTIVITY, *HUDSON RIVER, *RADIOACTIVITY EFFECTS, chemical properties, water properties, aquatic life, wildlife, temperatures, public health, bodies of water, rivers, running waters, streams, animals, aquatic animals, cation exchange, ion exchange, separation techniques, surface waters, salinity, river beds, streambeds, beds, fish, water temperature, hydrogen ion concentration.

268. McCullough, C. A., and J. D. Vayder, "DELTA-SUISUN BAY WATER QUALITY INVESTIGATION", in PROCEEDINGS OF THE NATIONAL SYMPOSIUM ON ESTUARINE POLLUTION, August 23-25, 1967, pp. 676-709. Department of Civil Engineering, Stanford University, Stanford, California.

Water quality tests were made to assess the present water quality of the Delta-Suisum Bay (San Francisco, California). A mathematical model was superimposed on the hydraulic model to predict conditions resulting from changes in the location and quantities of water released into the Delta. Fluorescent dye tracers were used to determine the impact of waste discharges at sensitive locations in the bay.

It was concluded that saline intrusion and other water quality control problems could be controlled by releases of fresh water from storage areas located in points around the Delta.

*MATHEMATICAL MODELS, *DYE RELEASES, *WATER QUALITY CONTROL, *CALIFORNIA, *TRACERS, geographical regions, Pacific coast regions, regions, southwest U. S., bays, bodies of water, tracking techniques, path of pollutants, mathematical studies, model studies, deltas, water pollution, waste disposal, water pollution control, control

269. McHugh, J. L., "ESTUARINE NEKTON", in ESTUARIES, 1967, pp. 581-620. American Association for the Advancement of Science, Washington, D. C.

The general physical characteristics, as well as the biological parameters and distribution, of nektonic organisms in estuaries are described. A discussion of estuarine fisheries is provided, giving figures on commercial landings and dollar values. The role of man as a predator in estuaries is discussed.

*ESTUARINE FISHERIES, *NEKTON, *MARKET VALUE, *FISH HARVEST, estuarine environment, aquatic habitats, bays, animals, aquatic animals, aquatic life, seston, aquatic environment, environment, fisheries, value, habitats, ecology, competition, productivity

270. McHugh, J. L., "MANAGEMENT OF ESTUARINE FISHERIES", in A SYMPOSIUM ON ESTUARINE FISHERIES, NINTH ANNUAL MEETING, Supplement No. 3, 1966, pp. 133-153. American Fisheries Society, Atlantic City, New Jersey.

Almost 2/3 (by value) of the U. S. commercial catch and most of the marine sport fish catch is composed of species that spend at least a part of their lives within land-bound estuaries. Dominance of estuarine species is especially great in catches along the Atlantic and Gulf of Mexico coasts. Around 1960, the sport fish catch was approximately 11 percent of the weight of the total commercial catch. In 1960 a catch of 590 million pounds of sport fish was estimated. For sport fishing, value is measured in money spent by the fishermen in pursuit of this recreation; for the commercial fisherman, value is measured by the dollar return on his catch.

There is a need for research into the problems of management and use conflict of estuarine fisheries.

*ESTUARINE FISHERIES, *COMMERCIAL FISHING, *SPORT FISHING, *VALUE, sport fish, commercial fish, fish management, animals, aquatic animals, aquatic life, fish, wildlife, water utilization, efficiencies, fishing, industries, recreation, water sports, evaluation, coasts, competing uses

271. McKean, R. N., EFFICIENCY IN GOVERNMENT THROUGH SYSTEMS ANALYSIS, 1966. John Wiley and Sons, Inc., New York.

This book presents a general discussion of the theory and practice of benefit-cost analysis. Of special interest are the discussions regarding the nature of benefits. McKean takes the view that the value of the incremental output, not the incremental value of the industry's output, is what should be considered a benefit. He concludes that secondary benefits should be included in the estimate of benefits only if unemployment would otherwise exist. A five-page bibliography is included.

*COST-BENEFIT ANALYSIS, *SYSTEMS ANALYSIS, *BENEFITS, *BIBLIOGRAPHIES, direct benefits, indirect benefits, government finance

272. McKee, Jack Edward, and Harold W. Wolf, editors, WATER QUALITY CRITERIA, 2nd edition, State of California, State Water Quality Control Board, Sacramento, California, Publication No. 3-A, 1963.

The technical and scientific literature pertaining to water quality is evaluated. An extensive bibliography of 3,827 references is included.

*WATER QUALITY, *BIBLIOGRAPHIES, water analysis, water properties, analysis

273. McKee, Paul W., "SEDIMENT", in PROBLEMS OF THE POTOMAC ESTUARY, January, 1964, pp. 40-46. Interstate Commission on the Potomac River Basin, Washington, D. C.

The control of erosion resulting from urban development has been largely ignored. This report presents some data to show the sediment yields of various areas in Maryland. Sediment yields from construction sites are from three to 100 times the average yield from rural areas.

*SOIL EROSION, *SURFACE RUNOFF, *CONSTRUCTION, *URBANIZATION, *MARYLAND, erosion, sediment discharge, sediment control, runoff, surface drainage, drainage, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions

274. McKee, Paul W., STATEMENT BEFORE THE SUBCOMMITTEE ON AIR AND WATER POLLUTION, April 17, 1968. Committee on Public Works, U. S. Senate, Washington, D. C.

The Department of Water Resources has requested investigation of the following topics:

1. Projection of electric power needs, cooling needs, and cooling water requirements for Chesapeake Bay through year 2010.
2. Optimal locations for future power plants considering all water uses involved.
3. The best plant design and operation for all environmental protection.
4. A review of the water uses and an estimate of the effects on them by the discharge of heated water.
5. The benefit to other uses of water by proper development of energy sources.

*THERMAL POLLUTION, *VIRGINIA, *MARYLAND, *ELECTRIC POWER INDUSTRY, *DESIGN, *FORECASTING, *WATER UTILIZATION, engineering structures, industrial plants, structures, control, water pollution, industrial water, water types, industry, sites, bays, efficiencies, southeast U. S., Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions, cooling water, powerplants, water requirements

275. McNatt, E. M., SEISMIC EXPLORATION AT SEA, Ocean Industry, Vol. 2, No. 6, June, 1967, pp. 30-33.

Problems involved in seismographic exploration at sea include: too little depth penetration, too much noise, too little resolving power, and too high a cost.

Present offshore seismic exploration survey costs per mile are roughly one-third of those on land.

*EXPLORATION, *SEISMIC STUDIES, *GEOPHYSICS, geologic formations, remote sensing, sounding, sub-surface investigations, analytical techniques, costs

276. McNulty, J. K., ECOLOGICAL EFFECTS OF SEWAGE POLLUTION IN BISCAYNE BAY, FLORIDA: SEDIMENTS AND THE DISTRIBUTION OF BENTHIC AND FOULING MACRO-ORGANISMS, Bulletin of Marine Science, Vol. 11, No. 3, 1961, pp. 394-447.

Harmful and fertilizing effects of sewage in Northern Biscayne Bay, Florida, were established by the quantitative distribution of benthic and fouling macro-organisms. Harmful effects, as indicated by absence of benthic life, were limited to within 200 yards of sewage outfalls, in greater than average depths. Fertilizing effects, as measured by abundance of benthic life, were most pronounced in a narrow band roughly 200 to 600 yards from sewage sources in shallow water with good tidal circulation and where the bottom consisted of firm sandy mud. The fouling organisms in highly polluted waters (greater than 10,000 MPN) were mainly tubiculous amphipods.

*BENTHOS, *WATER POLLUTION, *FLORIDA, invertebrates, amphipoda, fouling, stream biology, ecology, Atlantic coastal plain, coastal plains, geographical regions, Gulf coastal plain, animals, crustaceans, sewage disposal, plants, bacteria, sewage disposal, plants, bacteria, sewage bacteria, regions, southeast U. S., marine microorganisms, aquatic life, aquatic microorganisms, microorganisms, seston, outlets, aquatic animals

277. MEASURING THE IMPACT OF THE WATERBORNE COMMERCE OF THE PORTS OF VIRGINIA ON EMPLOYMENT, WAGES, AND OTHER KEY INDICES OF THE VIRGINIA ECONOMY, 1953-1965, Bureau of Population and Economic Research, University of Virginia, Charlottesville, Virginia, January, 1967.

This study is concerned with measuring the effects of selected economic components resulting from, and generated by, the waterborne commerce that flows through the ports of Virginia. The economic components used are employment, wages, state and local taxes, business and industrial activities. Because most of the port activity in Virginia occurs in the ports of Hampton Roads, the findings of this study were based primarily on the waterborne commerce at Hampton Roads. This report is the twelfth of a series undertaken by the University of Virginia for the Virginia State Ports Authority and published annually since 1957.

*HARBORS, *VIRGINIA, *ECONOMIC IMPACT, employment, wages, taxes, transportation, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, regions, southeast U. S., industries

278. Metcalf, T. G., and W. C. Stiles, VIRAL POLLUTION OF SHELLFISH IN ESTUARY WATERS, Journal of the Sanitary Engineering Division, Vol. 94, No. SA4, August, 1968, pp. 595-609.

Enteroviruses appear in oysters following pollution of estuary waters by waste-treatment plant effluents. Primary treatment, with or without chlorination, and stabilization pond effluents are regular contributors of enterovirus. Increased levels of chlorination accompanied by prolongation of retention time lead to a reduction in the number of viral isolations made from treated effluents. Enterovirus occurs in oysters collected from seawater containing less than 70 Coliform median MPN per 100 ml. Reduction of viral pollutants to undetectable levels in oysters by depuration in estuary waters requires three to six days. Depuration efficacy was adversely affected by large numbers of viral pollutants in oysters, by water temperature falling below 10 C, or both.

*OYSTERS, *WATER POLLUTION, *ESTUARINE ENVIRONMENTS, *SHELLFISH, marine animals, invertebrates, commercial shellfish, benthos, benthic fauna, fish, microorganisms, sewage treatment, sanitary engineering, public health, sewage disposal, engineering, environmental engineering, mollusks, chemical reactions, chlorination, viruses, wildlife, aquatic environments, environment, waste treatment, waste disposal, animals, aquatic animals, aquatic life

279. Middleton, Arthur Pierce, TOBACCO COAST, A MARITIME HISTORY OF CHESAPEAKE BAY IN THE COLONIAL ERA, 1953. The Mariners Museum, Newport News, Virginia.

This comprehensive history covers all uses of Chesapeake Bay and the activities related to it from the time of the earliest exploration to the Revolutionary War. It is heavily documented and is reputed by Maryland historians to be the best existing history of Maryland.

*HISTORY, *MARYLAND, *BAYS, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions

280. Mihursky, J. A., ON POSSIBLE CONSTRUCTIVE USES OF THERMAL ADDITIONS TO ESTUARIES, BioScience, Vol. 17, No. 10, November, 1967, pp. 698-702.

Thermal loading of an estuary, common in highly industrial areas, can cause damage in some ecosystems. It can also be used constructively, however, to maintain warm temperatures for the development of food items for commercially important species, and to stimulate growth of commercially important fish and shellfish.

*THERMAL POLLUTION, *BENEFICIAL USE, *COMMERCIAL SHELLFISH, *COMMERCIAL FISH, *BENEFITS, water pollution, animals, aquatic animals, aquatic life, invertebrates, shellfish, fish, wildlife, heated water, water types, water temperature, temperature, water properties, fish food organisms, ecology, ecosystems

281. Mihursky, J. A., and V. S. Kennedy, "WATER TEMPERATURE CRITERIA TO PROTECT AQUATIC LIFE", in A SYMPOSIUM ON WATER QUALITY CRITERIA TO PROTECT AQUATIC LIFE, American Fisheries Society, Transactions, Special Publication No. 4, Supplement to Vol. 96, No. 1, 1967, pp. 20-32.

This paper discusses the ecological significance of temperature in the aquatic habitat and attempts to use the principles discussed as standards of judgment concerning temperature regulations that may be necessary for preserving aquatic life in areas where the temperature regimes may be changed due to thermal pollution.

Three ecosystems are discussed: (1) cold-water salmonid streams, (2) warm-water centrarchid environments, and (3) estuaries.

*THERMAL POLLUTION, *WATER TEMPERATURE, *REGULATION, commercial fish, salmonids, environmental gradient, ecology, limiting factors, aquatic habitat, habitat, temperature, animals, water pollution, fish, aquatic animals, aquatic life, wildlife, ecosystems

282. Milliman, J. W., "THE ECONOMICS OF WATER PRODUCTION USING NUCLEAR ENERGY", in WATER PRODUCTION USING NUCLEAR ENERGY, 1966, pp. 49-73. The University of Arizona Press, Tucson, Arizona.

The economics of saline water conversion is discussed, with special emphasis being placed upon (1) alternatives to saline water conversion and (2) the economic issues involved in combined nuclear water and power facilities and the Bechtel Study of the feasibility of a combined water and power plant for Southern California.

The author outlines the economic analyses that have been associated with combined nuclear water-power plants in general, and is particularly critical of the Bechtel Study.

Among the major points and conclusions reached by the author are the following:

1. All known desalinization processes are capital intensive,
2. Even the most optimistic costs related to desalinization are not low when compared to current water costs and to other water source alternatives,
3. Dual purpose (power and water) plants achieve cost savings, but low costs are sensitive to stable outputs of both water and power,
4. Cities near sea-coasts, which have no obvious fresh water alternatives and which can absorb large blocks of power, would seem to be the best prospects for large-scale combination nuclear-desalting plants.

*DESALINATION PLANTS, *ECONOMIC FEASIBILITY, *CALIFORNIA, *NUCLEAR POWERPLANTS, desalination, saline water, costs, financial feasibility, economic justification, economics, Pacific coast regions, electric powerplants, industrial plants, southwest U. S., geographical regions, regions, demineralization, separation techniques, water purification, water treatment, buildings, engineering structures, structures, powerplants, water types

283. Mitchell, C. L., FISH PROTEIN CONCENTRATE SEEN POSSIBLE NEW INDUSTRY, Fisheries of Canada, Vol. 19, No. 11, May, 1967, pp. 12-15.

The author states that a fish protein concentrate industry in both Canada and the U. S. will develop shortly. Canada will be able to compete favorably with the U. S. in marketing FPC because it is estimated that the market prices of FPC in Canada and the U. S. will be $300/ton and $400/ton, respectively. FPC production costs are itemized.

*COMMERCIAL FISHING, *PROTEINS, *FISH HANDLING FACILITIES, *OPERATING COSTS, *FOODS, fish management, fisheries, production costs, fishing, industries, facilities, management, pricing, competitive prices, prices, competition, marketing, industrial production, costs, foreign countries, geographical regions, regions

284. Mock, C., IMPORTANCE OF GULF ESTUARIES AND PROBLEMS FACING OUR FISHERY RESOURCES, 11th International Game Fish Conference (1966), Proceedings, August, 1967, pp. 66-68.

The author states that the value of the sport fisherman to the American economic system probably exceeds that of the commercial fishery, and will in the future.

It is estimated that the renewable fishery resources of Gulf coastal waters yield 1/2 billion pounds of fish and shellfish; 90 percent of this is from five estuarine-dependent species.

The author argues that industrial and urban development in Texas will have or has had four major effects on estuaries:

1. Direct alteration or destruction of habitat
2. Reduction of tidal exchange between Gulf and estuary
3. Past or possible future depletion of fresh water to the bay oyster
4. Continuing deterioration of water quality through pollution.

The author feels that the future of the Texas estuary appears to be an escalation of these problems.

*VALUE, *GULF OF MEXICO, *COMMERCIAL FISHING, *SPORT FISHING, *WATER POLLUTION, *URBANIZATION, estuarine fisheries, recreation, gulfs, fish, central U. S., commercial fish, commercial shellfish, Texas, aquatic habitat, environment, tidal effects, coastal plains, geographical regions, mollusks, benthic fauna, benthos, marine animals, oysters, fisheries, fishing, industries, animals, aquatic animals, aquatic life, invertebrates, shellfish, water sports, bodies of water, surface waters, resources, wildlife, Gulf coastal plain, regions, southwest U. S.

285. Mock, Cornelius R., NATURAL AND ALTERED ESTUARINE HABITATS OF PENAEID SHRIMP, Gulf and Caribbean Fisheries Institute, Proceedings, Vol. 19, 1966, pp. 86-98.

This study demonstrates what can happen to a shrimp nursery area when it is altered by bulkheading. Two areas were chosen--one adjacent to an unaltered vegetative shore and the other near a concrete bulkhead. Both had similar hydrology and sediment types, but differed in the amount of organic detritus in the bottom sediments and in water depth. Intensive sampling over a ten-month period produced 2.5 times more brown shrimp (Penaeus Aztecus) and fourteen times more white shrimp (P. Setiferus) from the natural habitat than the bulkheaded area. This preference for the unaltered habitat depended on the physical rather than the hydrologic characteristics of the habitat.

*SHRIMP, *HABITATS, *BULKHEADS, *ENVIRONMENTAL EFFECTS, *AQUATIC PRODUCTIVITY, land reclamation, animals, aquatic animals, aquatic life, commercial shellfish, crustaceans, invertebrates, shellfish, environment, aquatic habitats, engineering structures, structures, hydraulic structures, walls, ecology, productivity

286. A MODEL LAND DEVELOPMENT CODE, Tentative Draft No. 1, American Law Institute, April 24, 1968.

This is a draft of proposals concerning the legal status of the planning process. The general conclusion is that there are some techniques of regulation that a governing body should not be able to use unless there is written evidence of forethought (i.e., written plans).

The proposed code is divided into 12 articles. The following is a summary of the code:

1. It grants power to local government to control land development.
2. It specifies the content of a land development plan.
3. It specifies the ways a locality can regulate development by zoning, architectural review, and eminent domain.
4. Compensation to land owners for loss of value because of coming under a new plan (e.g., zone changes from industrial to urban).
5. It suggests the standardization of procedures within the state for all permits for land development.

*LAND DEVELOPMENT, *GOVERNMENTS, *LEGISLATION, *PLANNING

287. MODERN SEWAGE TREATMENT PLANTS--HOW MUCH DO THEY COST, U. S. Public Health Service, Washington, D. C., 1964.

This study is based on a tabulation of design and cost information for 1504 sewage treatment projects constructed under the PL-660 program. Treatment processes covered include: (1) Imhoff-tank plants, (2) Imhoff-type plants, (3) primary treatment--separate sludge digestion plants, (4) stabilization ponds, (5) activated sludge plants, (6) trickling filters--separate sludge digestion plants, and (7) trickling filters--Imhoff-type plants.

*SEWAGE TREATMENT, *COSTS, *TREATMENT FACILITIES, *SLUDGE TREATMENT, *FILTERS, operation and maintenance, design, equipment

288. Moffett, A. W., THE SHRIMP FISHERY IN TEXAS, Texas Parks and Wildlife Department, No. 50, 1957.

Commercial shrimping is the most valuable sea fishery in the United States. At present, the Texas fleet lands about 64 million pounds of shrimp worth more than $25 million per year. The bait shrimp industry alone is a multimillion dollar enterprise. Although production is high, the shrimp supply is unstable.

*SHRIMP, *TEXAS, *SUPPLY, *FISHERIES, *MARKET VALUE, *BAIT FISHING, commercial shellfish, Gulf of Mexico, animals, aquatic animals, aquatic life, crustaceans, invertebrates, shellfish, gulfs, bodies of water, surface waters, central U. S., coastal plains, geographical regions, Gulf coastal plain, regions, southwest U. S., value, baits

289. Moore, B., "THE RISK OF INFECTION THROUGH BATHING IN SEWAGE-POLLUTED WATER", in PROCEEDINGS OF THE FIRST INTERNATIONAL CONFERENCE ON WASTE DISPOSAL IN THE MARINE ENVIRONMENT, July 22-25, 1959, pp. 29-38. Pergamon Press, New York.

Based on medical histories of gastro-enteritis, paratyphoid, and poliomyelitis of patients in seaside resorts, there seems to be little relation between infection and ocean swimming. While enteric fever has been frequently caused by sewage-polluted shellfish, swimming in sea-water into which sewage has been discharged is not a serious public health risk provided outfall sites have been chosen with reasonable care.

*PUBLIC HEALTH, *SWIMMING, *INFECTION, *WATER POLLUTION, *SEWAGE DISPOSAL, *OCEANS, water types, diseases, shellfish, animals, aquatic animals, aquatic life, beaches, municipal wastes, enteric bacteria, wastes, seawater, saline water, water pollution effects, water pollution sources, waste disposal, recreation, water sports, outlets, surface waters, bodies of water, bacteria microorganisms, plants

290. Morgan, Robert, WHEN DOES A FISHERY BECOME UNECONOMIC, World Fishing, No. 14, December, 1965, pp. 73-74, 77.

The author identifies the basic elements affecting optimum fishing rate as: (1) biological--both the elements affecting organic productivity and the rate of withdrawal by fishing or by mortality from other causes; and (2) economic--elements affecting both the cost of catching and demand. Changes in any of these elements will change the optimum effort of fishing necessary to yield the greatest difference between total economic input and output.

The purpose of this article is to point out that, in any consideration of overfishing or in any consideration of what is the best or optimum effort, every consideration should be given to economic factors (costs and prices), as well as to biological factors.

The author admits that many simplifications were made, especially in regard to the biological elements, in order to achieve a concise demonstration of the relations between the two elements.

The relations are illustrated with a diagram in which effort in standard vessel units is plotted against value and cost per week. The basic curve is that of total weight caught in relation to total effort expended, each taken as to an average over a period of time.

*FISH MANAGEMENT, *EXPENDITURES, *DEMAND, fishing, management, commercial fishing, industries, productivity, withdrawal

291. Morison, Samuel E., MARITIME HISTORY OF MASSACHUSETTS, 1921. Houghton-Mifflin Company, Boston and New York.

The author says that, although maritime Massachusetts enjoyed no natural advantage over other sections of the Atlantic coast, her apparent liabilities were converted into assets. The economic development of Merrimack River and Buzzards' Bay communities is analyzed. The interplay of human ingenuity and natural resources is stressed.

*COMMUNITY DEVELOPMENT, *ECONOMIC LIFE, *MASSACHUSETTS, *HISTORY, human resources, natural resources, geographical regions, New England, northeast U. S., regions, resources

292. Morris, S. B., OUTLOOK FOR ECONOMIC USE OF FRESH WATER FROM THE SEA, Journal of the Irrigation and Drainage Division, June, 1961, pp. 15-26.

The prospects for desalination systems in the United States are analyzed. The author is pessimistic except in special instances and along the Texas Gulf Coast.

*ECONOMIC FEASIBILITY, *DESALINATION, *TEXAS, central U. S., coastal plains, geographical regions, Gulf coastal plain, regions, southwest U. S., feasibility, demineralization, separation techniques, water purification, water treatment

293. Moss, F., RELATIONS BETWEEN SPORT AND COMMERCIAL FISHERMEN, 11th International Game Fish Conference (1966), Proceedings, August, 1967, pp. 69-74.

The author states that sport fishing should be considered an industry by virtue of its dollar value, number of participants, and size of catch. Some of the conflicts between sport and commercial fishermen are discussed and some solutions are suggested.

*SPORT FISHING, *COMMERCIAL FISHING, *INCOME, *SIZE, *COMPETITION, recreation, fishing, water sports, industries

294. Napier, Jeff W., "STATEMENT", in CLEAN WATER FOR THE NATION'S ESTUARIES, Transcript of Public Meeting, Biloxi, Mississippi, January 17, 1968, pp. 22-30. Federal Water Pollution Control Administration, Department of the Interior, S. E. Region, Atlanta, Georgia.

Estuaries are highly suitable areas for pleasure boating for several reasons, including: accessibility to urban areas and historical sight-seeing value. Estuaries also provide sheltered waters and a variety of fish species.

An estimated 40 million people go boating every year, and boat owners are estimated to spend about $3 billion annually. Boating has been growing at an annual rate of more than five percent.

Napier contends that sewage from pleasure boats is a highly negligible source of pollution, particularly in comparison to particular industrial plants.

*RECREATION, *BOATING, *RECREATION WASTES, *SPORT FISHING, *WATER POLLUTION, water quality, recreation facilities, wastes, water sports, sport fish, animals, aquatic animals, aquatic life, fish, wildlife

295. THE NATIONAL VALUE OF THE CHESAPEAKE BAY, Chesapeake Bay Authority Conference at Regional Advisor's Office, Baltimore, Maryland, 1933.

A series of reports is presented on the economic resources and problems of the Chesapeake Bay. The needfor interstate cooperation is recognized and discussed.

*HISTORY, *MARYLAND, *VIRGINIA, *BAYS, *VALUE, *INTERSTATE, resources, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions, southeast U. S.

296. Naylor, E., "EFFECTS OF HEATED EFFLUENTS UPON MARINE AND ESTUARINE ORGANISMS", in ADVANCES IN MARINE BIOLOGY, Volume 3, edited by Frederick S. Russell, 1965, pp. 63-104. Academic Press, London and New York.

The biological effects of heated effluents on estuarine life are discussed. The growth in volume of heated effluents from power plants in estuarine areas is indicated. It is suggested that there may be many situations where siting power plants in estuaries could be beneficial to the marine environment, as well as other situations where such would be detrimental.

*POWERPLANTS, *THERMAL POLLUTION, *ESTUARINE ENVIRONMENT, *GROWTH RATES, engineering structures, industrial plants, structures, aquatic environment, environment, rates

297. Nelson, Thurlow C., SOME ASPECTS OF POLLUTION, PARASITISM, AND INLET RESTRICTION IN THREE NEW JERSEY ESTUARIES, Estuaries, No. 83, 1967, pp. 203-211.

Since the oyster is a very sensitive biological indicator of conditions and is the best scientifically-known of all marine animals, the author uses the history of the oyster population in three New Jersey estuaries to illustrate the effect of nature and man on the ecology of the estuaries.

*HISTORY, *PARASITISM, *ESTUARINE ENVIRONMENT, *WATER POLLUTION EFFECTS, *OYSTERS, *NEW JERSEY, *ECOLOGY, commercial shellfish, pathology, aquatic environment, environment, animals, aquatic animals, aquatic life, benthic fauna, benthos, invertebrates, marine animals, mollusks, shellfish, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions, obstruction to flow

298. Newcombe, Curtis L., and Paul S. Dwyer, AN ANALYSIS OF THE VERTICAL DISTRIBUTION OF TEMPERATURE IN A DICHOTHERMIC LAKE OF SOUTHEASTERN MICHIGAN, Ecology, Vol. 30, No. 4, October, 1949, pp. 443-449.

Analysis of vertical water movement in Sodon Lake, Michigan, has been presented. Role of change of temperature with time, between depths six to 18 feet show exponential relationship, while depths below 27 feet show very slight temperature change. Coefficient of turbulence was found to be 1.81 square meters per month. The effect of density-differences induced by surface temperatures during seasonal transitions probably penetrates to about the mid-depth; and, in this connection, wind action is believed to play a secondary role varying in importance with the season.

*MICHIGAN, *THERMOCLINE, *TURBULENCE, *WATER CIRCULATION, *DENSITY STRATIFICATION, surface waters, standing waters, bodies of water, lakes, mathematical models, turbidity currents, central U. S., geographical regions, winds, circulation, stratification, regions, Great Lakes region, mathematical studies, model studies, currents (water), density currents, temperature

299. Newell, G. E., "POLLUTION AND ABUNDANCE OF ANIMALS IN ESTUARIES", in THE EFFECTS OF POLLUTION ON LIVING MATERIAL, edited by W. B. Yapp, Vol. 8, 1959, pp. 61-69. Institute of Biology, London, England.

The author provides a very brief and general discussion regarding the effects of pollution upon the marine biota in estuaries based upon observations in England and Wales.

*WATER POLLUTION EFFECTS, *FOREIGN COUNTRIES, *MARINE ANIMALS, ecology, environmental effects, animals, aquatic animals, aquatic life, geographical regions, regions

300. Nitsos, R. J., and Reed, P. H., THE ANIMAL FOOD FISHERY IN CALIFORNIA, 1961-1962, California Fish and Game, Vol. 51, No. 1, 1965, pp. 16-25.

Trawling produced 3.8 million pounds of fish in 1961 and 1.8 million pounds in 1962. These fish, some 60 species, are utilized primarily by the fur-farm industry.

*FISHERIES, *FURBEARERS, *TRAWLING, *FISH, *CALIFORNIA, production, fishing, animals, aquatic animals, aquatic life, wildlife, geographical regions, Pacific coast region, regions, southwest U. S., statistics, data collections

301. Nobe, Kenneth C., EMERGING NATIONAL POLICIES GOVERNING OUTDOOR RECREATION IN FEDERAL WATER DEVELOPMENT PROJECTS, Journal of Soil and Water, Vol. 19, No. 2, March-April, 1964, pp. 61-66.

The author states that a wide divergence among the policies of federal agencies affecting outdoor recreation components of multiple-purpose water development projects existed until quite recently. Now emerging is a more uniform national policy that recognizes outdoor recreation as a full partner in these projects. But a major job remains; translation of existing and emerging policy into procedures that will result in sound project formulation. The evolution of new recreation policies and their practical implications are discussed in this article.

*RECREATION, *FEDERAL GOVERNMENT, *MULTIPLE-PURPOSE PROJECTS, *WATER RESOURCES DEVELOPMENT, land management, projects, resource development, management

302. OCEANOGRAPHY--THE EMERGING SCIENCE OF THE SEA, Hayden Stone, Investment Research Department, October, 1967.

Present markets in the oceanography field and their future projections (1977) are described. In-depth analysis is made of offshore petroleum field and its related companies.

*OIL INDUSTRY, *DESALINATION, *OCEANOGRAPHY, *ECONOMIC PREDICTION, *COMMERCIAL FISHING, mining, fishing, oceans, bodies of water, surface waters, industries, exploitation, oil fields, forecasting, demineralization, separation techniques, water purification, water treatment, oil reservoirs

303. O'Connor, D. J., AN ANALYSIS OF THE DISSOLVED OXYGEN DISTRIBUTION IN THE EAST RIVER, Water Pollution Control Federation, Journal, Vol. 38, No. 11, November, 1966, p. 1813.

A mathematical model is presented to relate the change in dissolved oxygen levels along the length of the East River from the Upper Bay to Long Island Sound. The BOD input data from treatment plant effluents are tabulated. Calculated and observed dissolved oxygen and BOD in the East River are plotted.

*MATHEMATICAL MODELS, *DISSOLVED OXYGEN, *RIVERS, *NEW YORK, oxygen demand, biochemical oxygen demand, analysis, bodies of water, treatment facilities, northeast U. S., regions, running waters, streams, surface waters, effluents, Appalachian Mountain region, geographical regions, Great Lakes region

304. O'Connor, D. J., ESTUARINE DISTRIBUTION OF NONCONSERVATIVE SUBSTANCES, Journal of the Sanitary Engineering Division, Vol. 91, No. SA1, February, 1965, pp. 23-42.

The application of various mathematical methods to the determination of water quality and pollution conditions in estuaries is demonstrated. Many of the estuaries of the eastern coast of the United States are characterized by uniformity over the vertical and lateral planes. This condition, reducing the basic equations to a one-dimentional problem, is analyzed for three common coordinate systems that describe the geometry of the various estuaries. Various types of spatial and temporal inputs are considered. The final equations are used to define the longitudinal distribution of various nonconservative substances in the estuaries of the Delaware, the East, and the James Rivers. Data from both model tests and field surveys are provided for comparison with the predicted profiles.

*MATHEMATICAL MODELS, *WASTE ASSIMILATIVE CAPACITY, *WATER QUALITY, *DELAWARE RIVER, rivers, mathematical studies, model studies, bodies of water, interstate rivers, running water, streams, surface waters

305. O'Connor, D. J., ORGANIC POLLUTION OF NEW YORK HARBOR - THEORETICAL CONSIDERATIONS, Water Pollution Control Federation, Journal, Vol. 34, No. 9, September, 1962, p. 905.

The author presents a mathematical treatment of dissolved oxygen in the Hudson River and Upper Bay with respect to BOD loading from the various waste treatment plants. There is a good agreement between the observed values of dissolved oxygen and BOD to those obtained by using the mathematical model. Minimum dissolved oxygen occurred at the battery.

*MATHEMATICAL STUDIES, *BIOCHEMICAL OXYGEN DEMAND, *DISSOLVED OXYGEN, *NEW YORK, *HUDSON RIVER, *TREATMENT FACILITIES, oxygen demand, Appalachian Mountain region, Great Lakes region, streams, bodies of water, rivers, surface waters, running waters, northeast U. S., regions, geographical regions, harbors

306. O'Connor, D. J., OXYGEN BALANCE OF AN ESTUARY, Journal of the Sanitary Engineering Division, Vol. 86, No. SA3, May, 1960, pp. 35-55.

The dissolved-oxygen profile of rivers depends on the concentration of the organic material, its rate of oxidation, and the resulting rate of reaeration. The inter-relationship among geophysical and biochemical factors is described by a differential equation under a steady state condition. The proposed formulas defining the biochemical oxygen demand (BOD) decay and oxygen balance in an estuary agree reasonably with the observed data from the Delaware and James Rivers. The dissolved-oxygen profiles are more consistent and in better agreement than the BOD decay for these examples.

*BIOCHEMICAL OXYGEN DEMAND, *DISSOLVED OXYGEN, *MATHEMATICAL MODELS, *DELAWARE RIVER, surface waters, streams, running waters, rivers, reaeration, bodies of water, interstate rivers, mathematical studies, model studies, organic matters, aeration, aquatic plants, aquatic life, plants, oxygen demand

307. Odum, Eugene P., "STATEMENT", in CLEAN WATER FOR THE NATION'S ESTUARIES, Proceedings of the Georgia Public Meeting, Jekyll Island, Georgia, February 29, 1968, pp. 7-18. Federal Water Pollution Control Administration, Department of the Interior, S. E. Region, Atlanta, Georgia.

The importance of secondary waste treatment is stressed. It is further stressed that the natural high fertility and usefulness of estuaries "dictates that use and management should be based, as far as possible, on the concept of utilization of existing resources without changing the biological productivity and the basic flow pattern of the system". On the average, an acre of estuary is worth $500 and should be put to more valuable uses than landfill (where dry land is available) or open sewers for raw wastes.

As a basis for future planning, the author proposes a pattern of use zones which have been developed by the State of Georgia. These use regions are:

1. Industrial zones--subjected to extensive modification, where pollution control and maintenance of water quality are of paramount concern,
2. Natural-use zones--where the basic pattern of landscape remains undisturbed and recreation, fishing, seafood production, etc., are the primary objectives, and
3. Research zones.

*ZONING, *GEORGIA, *WATER QUALITY CONTROL, *SEWAGE TREATMENT, *ECOLOGY, *ATLANTIC COASTAL PLAIN, regulation, property values, water pollution control, water pollution treatment, water treatment, waste treatment, natural resources, resources, fish harvest, fishing, industries, Appalachian Mountain region, coastal plains, geographical regions, regions, southeast U. S., value, quality control, control, recreation, recreation facilities

308. Odum, Eugene P., "THE URGENT NEED FOR LANDSCAPE ZONING OF THE ESTUARINE REGION ACCORDING TO ECO-SYSTEM PRINCIPLES", in CLEAN WATER FOR THE NATION'S ESTUARIES, Proceedings of the Georgia Public Meeting, Jekyll Island, Georgia, November 29, 1968, p. 4. Federal Water Pollution Control Administration, Department of the Interior, S. E. Region, Atlanta, Georgia.

The article is a "plea for a package of three basic approaches in regard to estuaries:

1. Consideration of the estuarine landscape as one major ecological system (ecosystem) with inter-dependent components and functions;
2. Recognition by professionals and the public alike of the basic ecological laws that result in conflict between 'man' and 'nature' as the first step in resolving multi-purpose conflicts;
3. Need to establish immediately a ground swell of public opinion for landscape zoning as the only practical solution to desired multiple use objectives which must involve both preservation and use."

*ECOSYSTEMS, *MULTIPLE PURPOSE, "ZONING, *COMPETING USES, water utilization, regulation, efficiencies

309. Odum, Howard T., "ANALYSIS OF DIURNAL OXYGEN CURVES FOR THE ESSAY OF REAERATION RATES AND METABOLISM IN POLLUTED MARINE BAYS", in PROCEEDINGS OF THE FIRST INTERNATIONAL CONFERENCE ON WASTE DISPOSAL IN THE MARINE ENVIRONMENT, July 22-25, 1959, pp. 547-555. Pergamon Press, New York.

Studies were conducted in coastal marine waters in south Texas to assess the effect of pollution upon photosynthesis and reaeration through analysis of diurnal oxygen curves. Results of previous studies are summarized. Data from a field sampling program are presented, but no major conclusions are drawn.

*PHOTOSYNTHESIS, *REAERATION, *DISSOLVED OXYGEN, *WATER POLLUTION EFFECTS, Texas, central U. S., coastal plains, geographical regions, Gulf coastal plain, regions, southwest U. S., chemical reactions, diurnal

310. OIL SPILL RELIEF SEEN SOON, Oceanology International, Vol. 2, No. 6, September/October, 1967, p. 20.

This article discusses several oil pollution sources and related means of combating oil spillage.

*WATER POLLUTION SOURCES, *OIL INDUSTRY, *OIL WASTES, *WATER POLLUTION CONTROL, oil wastes, industries, organic matter, wastes, oil, control

311. OIL SPILLAGE STUDY; LITERATURE SEARCH AND CRITICAL EVALUATION FOR SELECTION OF PROMISING TECHNIQUES TO CONTROL AND PREVENT DAMAGE, Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, Washington, Report to Department of Transportation, United States Coast Guard, AD 666289, November 20, 1967.

A literature review and evaluation of the state of technology of prevention and control of major oil spillage on water. The restoration of the shore face and waterfowl habitats and the effects of oil pollution and defensive measures on aquatic life are also discussed. Specific areas of study summarized in the report include: technical aspects of tank vessel design as related to prevention of oil spillage, destruction or recovery of open sea oil slicks, protection and cleaning of the shore face and estuaries, and the effects of oil pollution and treatment agents on marine flora and fauna.

*DISASTERS, *OIL, *WATER POLLUTION, *BEACHES, *OILY WATER, water pollution effects, water pollution treatment, water treatment, oceans, bodies of water, surface waters, wildlife, land reclamation, aquatic life, wildlife habitats, environments, habitats, waterfowl, animals, birds

312. Okubo, A., HORIZONTAL DIFFUSION FROM AN INSTANTANEOUS POINT SOURCE DUE TO OCEANIC TURBULENCE, Chesapeake Bay Institute, Johns Hopkins University, Baltimore, Maryland, Report No. 32, 1962.

In this paper the author discusses horizontal turbulent diffusion of a patch of a diffusive substance released from an instantaneous point-source in the sea.

In Part I, a systematic derivation of some proposed concentration distributions for a patch is developed on the basis of a non-Markov hypothesis combined with knowledge of the rate of mean square dispersion. A new proposal for the concentration distribution is also presented. The solutions of others are critically discussed in comparison with available information about horizontal diffusion in the sea.

In Part II, a re-examination is made of the relations between the variance of the distribution and diffusion time and between the coefficient of eddy diffusion and the scale of the phenomenon, using accumulated data. In addition to this, some speculation about the two-dimensional horizontal energy spectrum of oceanic turbulence is presented.

*DIFFUSION, *OCEAN CIRCULATION, *TURBULENCE, mathematical models, eddies, circulation, movement, energy, water circulation, mathematical studies, model studies, currents (water) turbulent flow, 'flow

313. Okubo, A., A REVIEW OF THEORETICAL MODELS OF TURBULENT DIFFUSION IN THE SEA, Chesapeake Bay Institute, Johns Hopkins University, Baltimore, Maryland, Report No. 30, 1962.

A comprehensive survey of theoretical models for turbulent diffusion in the sea is presented. In the introductory sections, the author describes results of some recent observations of turbulent structure in the sea and points out some fundamental concepts which are necessary for the treatment of turbulent diffusion in the sea. Material presented in later sections falls into two parts: (1) Some of the important statistical properties associated with particle displacement in a turbulent velocity field are discussed without having information about the probability distribution functions. (2) A systematic derivation of some proposed concentration distributions for a patch of diffusive substance is shown on the basis of a non-Markov hypothesis combined with a knowledge of the rate of mean dispersion. Also some theoretical models for the mean concentration of substance released from a continuous fixed source are presented in comparison with available information. In addition to these, the author reviews briefly an empirical approach to the general problem of turbulent diffusion in the sea, where the dependence of the vertical coefficient of diffusion on the stratification of water is emphasized.

*MATHEMATICAL MODELS, *DIFFUSION, *TURBULENCE, *OCEAN CIRCULATION, mixing, dye releases, turbidity currents, radioactivity, stratification, water circulation, mathematical studies, model studies, analytical techniques, currents (water), density currents, circulation, movement

314. Olson, Theodore A., and Fredrick J. Burgess, editors, POLLUTION AND MARINE ECOLOGY, 1967. John Wiley and Sons, New York.

This book contains the published proceedings of the "Conference on the Status of Knowledge, Critical Research, Needs, and Potential Research Facilities Relating to Ecology and Pollution Problems in the Marine Environment". Various papers were presented under the following broad topics:

Part I.	Man's Resources in the Marine Environment
Part II.	Dynamics of the Littoral Marine Community
Part III.	Ecological Systems
Part IV.	Energy Transfer
Part V.	Interactions Between the Biota and the Chemical-Physical Environment
Part VI.	Parameters of Marine Pollution.

*ECOLOGY, *WATER POLLUTION, *LITTORAL, *ENERGY TRANSFER, *HUMAN RESOURCES, *ENVIRONMENTAL EFFECTS, transfer, resources

315. "OPTIMIZING COMBINATIONS OF OUTDOOR RECREATION AND OTHER ALTERNATIVE ENTERPRISES", in WATER RESOURCES RESEARCH CATALOG, Office of Water Resources Research, Department of the Interior, Washington, D. C., February, 1965.

This is a project description from the "Water Resources Research Catalog". The objectives listed are: "(1) To determine types of outdoor recreational opportunities suitable for private investors having different levels of management ability and other contributory resources. (2) To evaluate the optimum allocation of resources among relevant outdoor recreational and other land-using alternatives for selected cases and typical ownership situations."

The work proposed is described as follows: "Cost and return data will be collected from selected outdoor recreational enterprises. These data and other secondary enterprise data will be analyzed using existing linear programming models to estimate optimum allocation of available resources for specific and general land ownership situations. Description analyses will also be made of management functions with particular attention focused on unique management abilities and requirements necessary for the successful operation of outdoor recreation enterprises."

The project was conducted at Purdue University under Contract No. AG-IND-MS-1354. J. G. Callahan is conducting the research.

*OUTDOOR RECREATION, *RESOURCE ALLOCATION, *MODEL STUDIES, *COMPUTER MODELS, multiple purpose projects, water policy, projects, management

316. Orlob, G. T., R. P. Shubinski, and K. D. Feigner, "MATHEMATICAL MODELING OF WATER QUALITY IN ESTUARIAL SYSTEMS", in PROCEEDINGS OF THE NATIONAL SYMPOSIUM ON ESTUARINE POLLUTION, August 23-25, 1967, pp. 646-675. Department of Civil Engineering, Stanford University, Stanford, California.

This paper presents the theoretical and practical bases for the development of a mathematical model for digital computer simulation of quality changes, concentrating on the distribution in space and time of conservative constituents. It carries forward from an initial study aimed at providing the means for characterizing estuarial hydrodynamic behavior and utilizes a digital model of an estuartial network which was developed and verified for the Sacramento-San Joaquin Delta. This model was extended in a subsequent study for the Federal Water Pollution Control Administration as a part of its comprehensive investigation of the San Joaquin Master Drain and its effects on water quality in San Francisco Bay and the Delta. It formed the basic building block for the quality model reported in this paper.

*MATHEMATICAL MODELS, *WATER QUALITY, *CALIFORNIA, *COMPUTER MODELS, mathematical studies, model studies, water quality control, geographical regions, Pacific coast region, regions, hydrodynamics, fluid mechanics

317. Panlik, G. J., "DIGITAL SIMULATION OF NATURAL ANIMAL COMMUNITIES", in POLLUTION AND MARINE ECOLOGY, edited by T. A. Olson and F. J. Burgess, 1967, pp. 67-85. Interscience Publishers, New York.

This article describes the use of digital-computer simulation for ecological studies. The author believes that simulation techniques could be beneficially applied to ecological problems, but that they have not yet found such application except in selected instances.

The author describes various models and their application as well as the differences between analytical solutions and simulation approaches. Simulation languages of potential use in modeling ecological systems are discussed.

*ECOLOGY, *MODEL STUDIES, *DIGITAL COMPUTERS, *SIMULATION ANALYSIS, computer models, computers, equipment, instrumentation, systems analysis

318. Pannell, J. P. M., A. E. Johnson, and J. E. G. Baymont, AN INVESTIGATION INTO THE EFFECTS OF WARMED WATER FROM MARCHWOOD POWER STATION INTO SOUTHAMPTON WATER, The Institution of Civil Engineers, Proceedings, Vol. 23, September, 1962, pp. 35-62.

One of the principal conclusions of this research was that the tidal currents move the warm water for considerable distances in a layer below the cold fresh water and above cold salt water.

*THERMAL POLLUTION, *THERMAL POWERPLANTS, *HEATED WATER, *FOREIGN WATERS, thermal stratification, electric powerplants, engineering structures, industrial plants, powerplants, structures, water pollution, water types

319. Parkhurst, John D., Lester A. Haug, and Malcolm L. Whitt, OCEAN OUTFALL DESIGN FOR ECONOMY OF CONSTRUCTION, Water Pollution Control Federation, Journal, Vol. 39, No. 6, June, 1967, pp. 987-993.

Design requirements for submarine outfalls for disposal of metropolitan sewage wastes are described. Specification data and costs of construction are given for five major submarine outfalls on the Pacific Coast of the United States, with overall lengths ranging from 3,650 feet to 22,000 feet, and with design capacities ranging from 240 mgd to 600 mgd.

*OUTLET WORKS, *PACIFIC COAST REGION, *DESIGN CRITERIA, *SEWAGE DISPOSAL, conveyance structures, conduits, construction costs, capital costs, engineering structures, hydraulic structures, structures, waste disposal, costs, geographical regions, regions, design

320. PASSAMAQUODDY-ST. JOHN--HEARING BEFORE A SUBCOMMITTEE ON THE COMMITTEE ON PUBLIC WORKS, U. S. SENATE, 1964. U. S. Government Printing Office, Washington, D. C.

This report presents statements made and reports read into the record relating to a Senate hearing on August 12, 1964, concerning the Passamaquoddy-St. John project.

A supplemental report on the project from the Department of the Interior is reproduced in whole. The report states that: "The recommended benefit-cost ratio of the Passamaquoddy Dickey project is 1.47 to 1, of which the Dickey and Lincoln School benefit-cost ratio is 2.25 to 1 and the Passamaquoddy tidal power projects benefit-cost ratio is 1.04 to 1...These benefit-cost ratios were determined for a 100-year period of analysis with interest at three percent.

*TIDAL ENERGY, *COST-BENEFIT RATIO, *TIDAL POWERPLANTS, *COST-BENEFIT ANALYSIS, electric power, electric powerplants, engineering structures, industrial plants, powerplants, energy

321. Patrick, Ruth, STATEMENT BEFORE THE SUBCOMMITTEE ON AIR AND WATER POLLUTION, April 17, 1968. Committee on Public Works, U. S. Senate, Washington, D. C.

Dr. Patrick's statement is a description of a program of studies carried out in the vicinity of electric generating plants in Chesapeake Bay to determine the condition of the estuaries (Monocacy and Patuxent rivers) before the plants began to operate, particularly in reference to ecological conditions. Fifteen pages of tables accompany the statement.

*VIRGINIA, *ECOLOGY, *MARYLAND, *ELECTRIC POWERPLANTS, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., bays, southeast U. S., regions, engineering structures, industrial plants, powerplants, structures, bodies of water

322. Pearson, E. A., editor, PROCEEDINGS OF THE FIRST INTERNATIONAL CONFERENCE ON WASTE DISPOSAL IN THE MARINE ENVIRONMENT, University of California at Berkeley, 1959, 1960. Pergamon Press, New York.

Papers were presented in the following subject areas: (1) public health, (2) effects on marine biota, (3) design consideration, (4) nearshore oceanography, (5) receiving water analyses, and (6) estuarine hydrography.

*WASTE DISPOSAL, *HYDROGRAPHY, *WATER POLLUTION EFFECTS, environmental sanitation, water analysis, foreign countries, public health, design, oceanography, aquatic life, engineering, environmental engineering, hydrologic aspects, analysis, geographical regions, regions

323. Pearson, Erman, "TRACER METHODOLOGY AND POLLUTIONAL ANALYSIS OF ESTUARIES", in PROCEEDINGS OF THE FIRST INTERNATIONAL CONFERENCE ON WASTE DISPOSAL IN THE MARINE ENVIRONMENT, July 22-25, 1959, pp. 556-567. Pergamon Press, New York.

The general estuarine pollution problem is reviewed with respect to classical approaches, particular solutions, and specific technical considerations and limitations. A rational approach to the problem includes resolution of the waste space-concentration distribution, determination of eddy diffusivity coefficients and residence time of the waste in the estuarine system.

The need for and justification of the use of tracers is presented and practical tracers are discussed. It is concluded that Orzan (dried spent sulfite waste liquor solids) is the most economic and technically feasible tracer that might be used in estuarine pollution studies. Details are presented relative to tracer characteristics and methodology, field techniques, and data analysis. The use of tracer techniques for resolution of the relative pollutional contribution of a single waste being discharged into a complex of discharges is described. A general graphical solution for computing the quality of non-conservative waste present in an estuarine system at steady-state is presented for varying first-order rate constants and for a considerable range in residence time.

*TRACERS, *DIFFUSION, *WASTE DISPOSAL, *ANALYTICAL TECHNIQUES, *SULFITE LIQUORS, waste dilution, effluents, currents (water), mathematical models, tracking, techniques, water pollution, mathematical studies, model studies.

324. Pence, George D., Jr., John M. Jeglic, and Robert V. Thomann, "THE DEVELOPMENT AND APPLICATION OF A TIME-VARYING DISSOLVED OXYGEN MODEL", in PROCEEDINGS OF THE NATIONAL SYMPOSIUM ON ESTUARINE POLLUTION, August 23-25, 1967, pp. 537-585. Department of Civil Engineering, Stanford University, Stanford, California.

A one-dimensional time-varying mathematical model for the simulation of dissolved oxygen in an estuary is developed along with a numerical integration procedure for computer solution. Some applications of the model are presented, including a verification of one year of data and several control scheme simulations. Application of the model to variables other than oxygen and other hydraulic regimes is discussed briefly.

*DISSOLVED OXYGEN, *MATHEMATICAL MODELS, *MODEL STUDIES, *COMPUTER MODELS, mathematical studies

325. Picton, Walter L., WATER RESOURCES DEVELOPMENTS CAPITAL INVESTMENT VALUES 1900-1975, Water and Sewerage, Industry and Utilities Division, Business and Defense Services Administration, Department of Commerce, Washington, D. C., June, 1959.

Estimates of actual investment in 1954, deficiencies in investment in 1954, projections of investment to 1975, and obsolescence during the 1954-1975 period are presented. Categories include: water supply and treatment, water utilities, hydro power, thermal power, industrial and miscellaneous water works, rural domestic, irrigation, navigation, flood control, waste collection and treatment, sewerage utilities, industrial and miscellaneous wastes, and rural domestic.

*INVESTMENT, *FORECASTING, *WATER RESOURCES DEVELOPMENT, water utilization, resource development, water supply, supply, water treatment, thermal power, water works, utilities, irrigation, navigation, flood control, control, water control, waste disposal, industrial wastes, wastes, domestic wastes, farm wastes

326. Pillay, T. V. R., LAND RECLAMATION AND FISH CULTURE IN THE DELTAIC AREAS OF WEST BENGAL, INDIA, Progressive Fish-Culturist, Vol. 19, No. 3, July, 1957, pp. 99-103.

A general description is given of an estuarine land reclamation method. The method employs tidal flows in the delta of the Ganges River in India and requires almost 15 to 20 years to reclaim land suitable for joint production of rice and fish.

*LAND RECLAMATION, *FISH FARMING, *TIDAL EFFECTS, *FOREIGN WATERS, *DELTAS, rice, fish, agriculture, agronomic crops, cereal crops, crops, field crops, streams, surface waters, grasses, monocots, plants, animals, aquatic animals, aquatic life, wildlife, water types, rivers, bodies of water, running waters

327. Pincus, L., J. C. Thomas, and J. A. Hansen, MARINE SPORTFISHING SURVEY OF SOUTHERN CALIFORNIA PIERS AND JETTIES, 1963, California Fish and Game, Vol. 53, No. 2, 1967, pp. 88-104.

The authors supply statistics on the number of people using piers and jetties for recreational fishing. Since a considerable number of people are using these piers and jetties, it is recommended that pier-development programs be continued.

*SPORT FISHING, *PIERS, *JETTIES, *CALIFORNIA, recreation, fishing, water sports, engineering structures, coastal structures, geographical regions, Pacific coast region, regions, southwest U. W., statistics, data collections

328. PLAN DEVELOPING FOR UNDERWATER PARKS, Parks and Recreation, Vol. 3, No. 9, September, 1968, pp. 11-12.

A survey is being conducted along the coast of California to investigate its resources, geological features, and the destruction of animal life in the tidal pools. The survey is part of a plan to create a series of underwater parks in the state. Underwater sports and marine science will be stressed.

*UNDERWATER, *PARKS, *CALIFORNIA, recreation, surveys, aquatic environment, shores, scuba diving, water sports, environment, geographical regions, Pacific coast region, regions, southwest U. S., coasts, coastal areas, coastlines

329. POLICIES, STANDARDS, AND PROCEDURES IN THE FORMULATION, EVALUATION, AND REVIEW OF PLANS FOR USE AND DEVELOPMENT OF WATER AND RELATED LAND RESOURCES, Senate Document No. 97, 87th Congress, Second Session, U. S. Government Printing Office, May 29, 1962.

The purpose of this document was to establish official Executive policies, standards, and procedures for uniform application in the formulation, evaluation, and review of comprehensive river-basin plans and individual project plans for use and development of water and related land resources. The document describes, in very broad terms, the nature and scope of plans acceptable to the Federal establishment. Definitions are provided for the various benefits arising from water resource investments. Definitions of costs and means for measuring costs are provided.

The document provides a very broad framework within which there is much opportunity for wide variations in the applications of the principles set forth.

*FEDERAL GOVERNMENT, *STANDARDS, *WATER UTILIZATION, *WATER RESOURCES DEVELOPMENT, *LAND RESOURCES, *COSTS, administration, benefits, cost analysis, governments, analysis, mathematical studies, efficiencies, resources development, natural resources, resources, planning

330. POLICING THE OIL INDUSTRY, Oceanology International, Vol. 2, No. 3, May/June, 1967, p. 11.

The author discusses various conflicts between the petroleum industry and other interests.

*OIL INDUSTRY, *WATER POLLUTION SOURCES, oil, industries, oil wastes, organic matter, wastes

331. POLLUTION OF THE HUDSON RIVER AND ITS TRIBUTARIES, Department of Health, Education, and Welfare, Public Health Service, Division of Water Supply and Pollution Control, September, 1965.

This report contains some information related to the Hudson Estuary, although it is difficult to separate the information on the River from that relating strictly to the Estuary. Information on recreation and shipping in the estuary is provided, including a list of public beaches and waterfront parks.

*HUDSON RIVER, *RECREATION, *WATER POLLUTION, *SHIPS, beaches, parks, bodies of water, rivers, running waters, streams, surface waters

332. POLLUTIONAL EFFECTS OF PULP AND PAPER MILL WASTES IN PUGET SOUND, Department of the Interior, Federal Water Pollution Control Administration, Northwest Regional Office, Portland, Oregon, and Washington State Pollution Control Commission, Olympia, Washington, March, 1967.

The author's conclusions are primarily qualitative rather than quantitative. Specific recommendations are made concerning actions that the mills should be required to undertake to abate pollution, but these recommendations are apparently not based on any quantitative estimates of damage caused to competing uses, nor on estimates of investment outlays which would be required to satisfy the recommendations.

*WATER POLLUTION CONTROL, *COSTS, *PULP AND PAPER INDUSTRY, *WASHINGTON, water pollution, pollution abatement, water pollution effects, pulp wastes, water pollution treatment, control, abatement, industries, industrial wastes, wastes, geographical regions, Pacific coast region, Pacific northwest U. S., regions, water treatment

333. POLLUTIONAL EFFECTS OF STORMWATER AND OVERFLOWS FROM COMBINED SEWER SYSTEMS, A PRELIMINARY APPRAISAL, Public Health Service, Publication No. 1246, 1964.

This is a collection and analysis of the available information relating to the subject, including questionnaire information obtained for the purposes of the study. A principal conclusion is that some 59 million people live in U. S. communities now served by sewer systems which allow overflows.

The annual average overflow is estimated to contain three to five percent of the untreated sewage and, during storms, as much as 95 percent of untreated sewage. Completely satisfactory cost estimates were not available, but it appears that to provide complete separation throughout the country the order of magnitude would be in the $20-30 billion range.

This report presents and analyzes sundry data for major cities, such as severed population, type of sewers, type of treatment facilities, estimated cost of total or partial separation on per acre and per capita bases.

*STORM DRAINS, *CAPITAL COSTS, *OVERFLOW, *TREATMENT FACILITIES, *SEWERS, water pollution control, water pollution sources, water pollution effects, sewerage, flow separation, drains, storm runoff, runoff, control, conduits, conveyance structures, engineering structures, hydraulic structures, structures, costs

334. PORT INFORMATION SOURCES, Division of Ports and Systems, Office of Maritime Promotion, Maritime Administration, Washington, D. C., September, 1966.

A list of all publications and available information sources on port administration, port operation, port design, and port construction is presented.

*HARBORS, *ADMINISTRATION, *BIBLIOGRAPHIES, *OPERATIONS, *DESIGN, *CONSTRUCTION, data collections, publications, technical writing, information retrieval, design data, fabrication

335. PORTS OF THE WORLD, 1967. Shipping World, Benn Brothers, Ltd., Bouverie House, Fleet Street, London, England.

The locations and available facilities of the major ports of the world are given. The information includes data on port charges, pier space, anchorages, inland transportation, bunkers, repair facilities, and some traffic data. Pages 471 through 532 include data on United States ports.

*HARBORS, *DATA COLLECTIONS, *FACILITIES, equipment, ships

336. Preddy, W. S., and B. Webber, THE CALCULATION OF POLLUTION OF THE THAMES ESTUARY AS A THEORY OF QUANTIZED MIXING, International Journal of Air and Water Pollution, Vol. 7, No. 8, 1963, pp. 829-843.

This paper describes the mathematical methods which have been used to relate water quality in the Thames Estuary to the amount and nature of organic and thermal pollution discharges, the positions of discharge, rates of waste oxidation, reaeration rates, and the flow of water from tributaries and effluents. Water quality parameters employed are dissolved oxygen, ammoniacal nitrogen, and oxidized nitrogen.

*WATER QUALITY, *MATHEMATICAL MODELS, *WATER POLLUTION, *MIXING, *FOREIGN COUNTRIES, dissolved oxygen, waste assimilative capacity, mathematical studies, model studies, effluents, discharge (water), organic wastes, wastes, thermal pollution, reaeration, nitrogen, gases, geographical regions, regions

337. Prest, A. R., and R. Turvey, COST-BENEFIT ANALYSIS: A SURVEY, The Economic Journal, Vol. LXXV, No. 300, December, 1965, pp. 683-735.

A comprehensive review of cost-benefit analysis is presented. The history of cost-benefit analysis, general principles of application, pertinent issues involved, and applications to water and other subjects are examined. An excellent bibliography is included.

*COST-BENEFIT ANALYSIS, *HISTORY, *BIBLIOGRAPHIES, *SURVEYS, water resources, resources

338. Pritchard, D. W., ESTUARINE CIRCULATION PATTERNS, American Society of Civil Engineers, Proceedings, Vol. 81, No. 717, 1955, pp. 1-11.

The salinity gradients, distinct density, stratification, and circulation pattern in estuaries are described. Conditions which develop in an estuary depend primarily upon the river flow, tidal flow, width and depth of the estuary. Other things being equal, an estuary tends to shift from Type A (highly stratified) through Type B (moderately stratified) to Type C or D (vertically homogeneous) with decreasing river flow, increasing tidal velocities, increasing width, and decreasing depth. The salt balance at a given point in various types of estuaries is expressed by differential equations.

*CIRCULATION, salinity, physical parameters, mathematical models, density, water properties, currents (water), tides, mathematical studies, model studies, chemical properties, water properties, stratification, physical properties, ocean currents

339. Pritchard, D. W., "ESTUARINE HYDROGRAPHY", in ADVANCES IN GEOPHYSICS, Vol. 1, 1952, pp. 243-279. Academic Press, New York.

Until recently, relatively little work has been directed toward understanding the structure and circulation of inshore waters, particularly bays and estuaries which are actually among the most important areas for fisheries production as well as other human use problems. The author classifies estuaries in terms of fresh-water inflow and evaporation and calls these "positive, inverse, and neutral estuaries". He classifies them in terms of geomorphological structure and lists coastal-plain, deep-basin or fiord, and bar-built estuaries. Discussed also is Stommel's classification scheme based on the predominant physical causes of movement and mixing of water in estuaries. These are: tidal, meteorological (wind), and river flow or a combination with one being dominant. Pritchard uses all three types of classification with Stommel's being a "subclassification".

Physical structure and circulation patterns in the three main types of estuaries are discussed.

The flushing of tidal estuaries is discussed and critical flushing parameters are established.

*HYDROGRAPHY, *CIRCULATION, *SALINE WATER-FRESHWATER INTERFACES, *CLASSIFICATION, hydrologic aspects, hydrologic cycle, inflow, boundaries (surfaces), interfaces, mixing, fresh water, water types, estuarine fisheries, fisheries

340. Pritchard, D. W., THE PHYSICAL HYDROGRAPHY OF ESTUARIES AND SOME APPLICATIONS TO BIOLOGICAL PROBLEMS, 16th North American Wildlife and Natural Resources Conference, Transactions, 1951, pp. 368-376.

A two-year study of Chesapeake Bay revealed that the most important physical variable governing the dynamic structure of estuaries is salinity. Salinity variations within the bay are described. A study on the James River oyster seed bed area indicated that the most productive bars lie along the river side. Physical and biological factors concerning fisheries, crab larvae, and croker spawn cultures are also discussed.

*MARYLAND, *SALINITY, *AQUATIC PRODUCTIVITY, *HYDROGRAPHY, hydrologic aspects, Appalachian Mountain region, coastal plains, Atlantic coastal plain, geographical regions, bays, fisheries, oysters, bodies of water, animals, aquatic animals, aquatic life, benthic fauna, northeast U. S., regions, crabs, commercial shellfish, crustaceans, benthos, invertebrates, marine animals, mollusks, shellfish productivity

341. Pritchard, D. W., A PRELIMINARY ESTIMATE OF THE EFFECT OF DIVERSION OF FLOW FROM THE SUSQUEHANNA RIVER ON THE SALINITY OF THE UPPER CHESAPEAKE BAY, presented to the Eleventh Meeting, Susquehanna River Basin Coordinating Committee, Elmira, New York, 1965.

The effects of flow from the Susquehanna River into the Chesapeake Bay upon the salinity of the Bay are reported. The relationship depends not only upon the river discharge in the recent past but also in a complex way upon the flow history. The author recommends construction of an adequately scaled hydraulic model to investigate the variables involved.

*SALINITY, *BAYS, *MODEL STUDY, *RIVER FLOW, *DIVERSION, Maryland, Virginia, chemical properties, water properties, bodies of water, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions, southeast U. S., channel flow, flow, streamflow, management, routing, water management (applied)

342. Pritchard, D. W., and H. H. Carter, ON THE PREDICTION OF THE DISTRIBUTION OF EXCESS TEMPERATURE FROM A HEATED DISCHARGE IN AN ESTUARY, Chesapeake Bay Institute, Johns Hopkins University, Technical Report No. 33, February, 1965.

The authors believe "that the techniques described here will have general application; however, this paper treats the specific case of the heated effluent from the PEPCO Chalk Point Power Plant on the Patuxent estuary in Maryland, which should serve to illustrate the basic concepts".

*THERMAL POLLUTION, *MARYLAND, *FORECASTING, thermal power, thermal powerplants, water pollution, electric powerplants, engineering structures, industrial plants, powerplants, structures, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions

343. Pritchard, Donald W., "THE MOVEMENT AND MIXING OF CONTAMINANTS IN TIDAL ESTUARIES", in PROCEEDINGS OF THE FIRST INTERNATIONAL CONFERENCE ON WASTE DISPOSAL IN THE MARINE ENVIRONMENT, July 22-25, 1959, pp. 512-525. Pergamon Press, New York.

The process which controls the movement and dispersion of a waterborne contaminant within and through a tidal estuary is presented here, in both narrative and mathematical forms. Emphasis is placed on problems related to material which occurs in dissolved form in the receiving waters, or which is completely miscible with these waters and does not separate from them under the action of gravity.

*DIFFUSION, *WASTES, *TIDAL WATERS, *MIXING, currents (water), waste dilution, mathematical model, waste disposal, solubility, physical properties, dispersion, water pollution, model studies

344. PROCEEDINGS OF THE INTER-AGENCY SEDIMENTATION CONFERENCE, 1963, Miscellaneous Publication No. 970, June 1965. Department of Agriculture, Washington, D. C.

Symposium 3. Sedimentation in Estuaries, Harbors and Coastal Areas.
Sixteen papers were delivered on sedimentation in estuarine environments. Topics included were: marine influences on sedimentation; effects of dredging techniques on sedimentation in general, Baltimore Harbor specifically; means of inducing sediment deposition and removal; and dredge spoil disposal in San Francisco Bay.

*SEDIMENTATION, *DREDGING, *HARBORS, *MARYLAND, *CALIFORNIA, erosion, sediment control, sediment distribution, estuarine environment, aquatic environment, environment, coasts, geographical regions, Pacific coast region, regions, southwest U. S., Appalachian Mountain region, Atlantic coastal plain, coastal plains, northeast U. S.

345. 1967 PROCEEDINGS OF WODCON, World Dredging Conference, Palos Verdes Estates, California, May, 1967.

This is a compilation of the papers read at the World Dredging Conference, May 6-8, 1967, held in New York City. Topics covered were: dredge design, coastal and reclamation dredging, sediment sampling systems, dredging developments, and ocean mining.

*DREDGING, *RECLAMATION, *MINING, *SEDIMENTS, *SAMPLING, land reclamation, coastal engineering, engineering, hydraulic mining

346. PUBLIC WORK NEEDS - MARINE PORT FACILITIES, Maritime Administration, Department of Commerce, June, 1966.

Prepared for the Joint Economic Committee of the Congress, this report describes the existing ports and terminal facilities of the United States, the trend of capital outlays for port development, and the needs and prospective capital outlays for port development 1966-1975. The Maritime Administration projected that the capital requirements for port terminal facilities during the decade 1966-1975 are estimated to be $1,281.5 million. $605.7 million are allocated to ports on the three sea coasts. It is believed Federal financial assistance will not generally be required.

*HARBORS, *CONSTRUCTION COSTS, *PLANNING, *ESTIMATED COSTS, data collections, federal government, coasts, construction, cost allocation, cost analysis, cost trends, long-term planning, administration

347. Rademacher, J. M., "SPILL POLLUTION - ITS EFFECTS AND CONTROL", in MARINE, ESTUARIAN, AND RIPARIAN POLLUTION DISASTERS AND THEIR CONSEQUENCES, Ocean Resources Subcommittee Meeting, December 12, 1967. National Security Industrial Association, Washington, D. C.

The author describes three incidents in which toxic material was accidentally spilled into the water. In all three incidents damage to marine wildlife was disastrous, and the lack of effective combative operations in these three cases pointed toward the need for a "pollution emergency control program". Such a program is described.

*DISASTERS, *WATER POLLUTION TREATMENT, *WATER POLLUTION EFFECTS, fishkill, wildlife, water pollution

348. Radoff, Morris L., editor, THE OLD LINE STATE, A HISTORY OF MARYLAND, 1956. Historical Record Association, Annapolis, Maryland.

This volume is comprised of articles discussing particular developmental factors in the history of Maryland, such as natural resources and commerce. Several regions are also treated separately, such as Southern Maryland and the Eastern shore. In general, the volume is socio-political in nature.

*HISTORY, *MARYLAND, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions, social aspects, political aspects, natural resources, resources

349. Raphael, Jerome, M., PREDICTION OF TEMPERATURE IN RIVERS AND RESERVOIRS, Journal of the Power Division, Vol. 88, No. P02, July, 1962, p. 157.

A procedure is presented for predicting the temperature of various water bodies from weather records, inflow and outflow characteristics, and the surface area and volume of the body of water. The method can be applied to shallow lakes, flowing streams, and detention reservoirs in which the thermocline is absent and water is stirred by wind or current. A numerical method is outlined which combines the atmospheric conditions such as air temperature, relative humidity, cloud cover, wind speed, and barometric pressure on short wave insolation and reflectance, long-wave radiation from atmosphere and water, evaporation, conduction, and advection. An example is given of the use of the method, which is easily adaptable to machine computation. The method should find application in the comparison of temperatures of streams with and without detention reservoirs and in the dissipation of heat from industrial sources in streams and lakes.

*THERMAL POLLUTION, *MATHEMATICAL MODELS, *WATER TEMPERATURE, *WEATHER DATA, *INFLOW, *DISCHARGE (WATER), water pollution, water types, heated water, model studies, thermocline, heat transfer, conduction, radiation, temperature, water properties, mathematical studies, transfer, standing waters, impoundments, rivers, bodies of water, running waters, streams, surface waters, reservoirs, lakes

350. Rawls, Charles K., "AQUATIC PLANT NUISANCES", in PROBLEMS OF THE POTOMAC ESTUARY, January, 1964, pp. 51-56. Interstate Commission on the Potomac River Basin, Washington, D. C.

The author presents a brief discussion of the two introduced water-plant nuisances in the Potomac Estuary, the water chestnut (Trapa natans L.) and the Eurasian water nilfoil (Myriophyllum spicatum L.). He discusses the problems posed by their occurrence, the extent of infestation, and current control methods and their effectiveness.

*MARYLAND, *VIRGINIA, *AQUATIC WEEDS, *VEGETATION EFFECTS, *AQUATIC WEED CONTROL, aquatic plants, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions, southeast U. S., aquatic life, plants, weeds

351. Rawn, A. M., "FIXED AND CHANGING VALUES IN OCEAN DISPOSAL OF SEWAGE AND WASTES", in PROCEEDINGS OF THE FIRST INTERNATIONAL CONFERENCE ON WASTE DISPOSAL IN THE MARINE ENVIRONMENT, July 22-25, 1959, pp. 6-11. Pergamon Press, New York.

Ocean disposal remains a very attractive method of dispensing with sewage and wastes because it is uncomplicated and inexpensive. Lately, however, it has become evident that the practice of sewage outfall has been detrimental to many water uses, such as recreation.

An experiment is described which changed much of the operating characteristics at an ocean outfall site. Some of the characteristics affected were: influence of direction of discharge from outfall (i.e., whether vertical or horizontal) upon initial depth; relation between length of path of rising column (and consequently depth and velocity of discharge) to initial dilution; relation of initial dilution to spread of field of contamination; and relation of length of rising column to thickness of field of contamination.

*OUTLETS, *MUNICIPAL WASTES, *SEWAGE DISPOSAL, *OCEANS, *RECREATION, Pacific Ocean, bodies of water, surface waters, wastes, sewage, water pollution sources, water pollution, waste disposal, sewage effluents, effluents, water sports

352. Ray, Carleton, INSHORE MARINE CONSERVATION, First World Conference on National Parks, National Park Service, Department of the Interior, Washington, D. C., June 30-July 7, 1962, pp. 77-87.

The major theme in this paper is a proposal to project the ideas and support of land and fresh water conservation to the marine environment. This would necessitate the establishment of: (1) parks, (2) sanctuaries for research and study, (3) management programs, and (4) regulations and enforcement.

To support his contention, Ray calls on five illustrative points:

1. The sea has productive and desert areas. Inshore areas are most productive.
2. The sea has been utilized with replenishment (by man) for centuries.
3. Commercial fishing can be decimated in productive inshore areas.
4. There is limited knowledge of the marine environment.
5. The sea is a three dimensional environment with three atmospheres to protect.

*AQUATIC HABITATS, *FISH CONSERVATION, *SOIL CONSERVATION, *WATER CONSERVATION, *REGULATION, parks, water resources development, fish management, conservation, commercial fishing, management

353. Redford, Polly, VANISHING TIDELANDS, Atlantic Monthly, Vol. 219, June, 1967, pp. 75-83.

This is a journalistic portrayal of the U. S. estuaries through the eyes of a conservationist. It was written in support of Dingell's bill HR 25 and discusses some of its points. The article outlines the contamination of the Merrimack River north of Boston. Efforts by conservationists to buy sections of natural estuarine habitat are discussed.

*LEGISLATION, *WATER POLLUTION, *WILDLIFE CONSERVATION, *HABITAT IMPROVEMENT, water conservation, conservation, habitats, environment, management, wildlife management, tidal marshes, marshes, wetlands, adoption of practices

354. Reish, D. J., EFFECT OF POLLUTION ON MARINE LIFE, Industrial Wastes, Vol. 2, No. 5, September-October, 1957, pp. 114-118.

Studies of Los Angeles-Long Beach before, during, and periodically after dredging show the consequences of pollution on the ecology of marine life. Five bottom surveys were made of these harbors between August, 1951, and December, 1955, in order to determine the influence of dredging upon the bottom-dwelling animals. An increase in the number of species occurred shortly after dredging and decreased with each successive survey. Equilibrium with respect to bottom conditions developed a year after dredging.

*DREDGING, *ECOLOGY, *BENTHOS, *WATER POLLUTION EFFECTS, sediments, bottom sediments, aquatic life, surveys

355. REMARKS BY BRIGADIER GENERAL JOHN A. B. DILLARD, Division ENGINEER, SOUTH PACIFIC, San Joaquin and Contra Costa Navigation Interests, Concord, California, January 20, 1967.

The author's remarks cover the relation of deep draft shipping to regional economic development. Local industry has become more and more dependent on low-cost sea transportation. The author suggests a central loading and unloading station for oil and bulk products, thus requiring only one deep draft channel across the Bar in the port of Stockton, California.

*CALIFORNIA, *SHIPS, *ECONOMIC IMPACT, transportation, navigation, civil engineering, engineering

356. Remirez, Raúl, THERMAL POLLUTION: HOT ISSUE FOR INDUSTRY, Chemical Engineering, Vol. 75, No. 7, March 25, 1968, pp. 48-52.

This article discusses the problem of thermal pollution and presents some current information on the subject.

The article states that "...about 70% of the industrial thermal-pollution load is attributed to the steam electric-power industry". It also states that nuclear plants, expected to be a large percent of future construction, reject about 50 percent more heat than fossil fuel plants. Reservoirs or cooling towers could alleviate the problem, but might increase the cost of electricity one to five percent. Reuse of now wasted heat is one possibility.

*THERMAL POLLUTION, *NUCLEAR POWERPLANTS, *THERMAL POWERPLANTS, *COOLING, water pollution, electric powerplants, engineering structures, industrial plants, powerplants, structures, steam turbines, equipment, turbines, cooling towers, heated water, water types, water pollution sources, cost comparison, analysis, cost analysis, mathematical studies

357. Renn, Charles E., MAN AS A FACTOR IN THE COASTAL ENVIRONMENT, Twenty-First North American Wildlife Conference, Transactions, March, 1956, pp. 470-473.

A general discussion of ways in which the development of cities influences the estuarine environment. A well-written and balanced discussion of the general effects of economic growth on the estuarine environment.

*WATER POLLUTION, *URBANIZATION, cities, regions, environment

358. A REPORT ON POLLUTION OF THE NATION'S WATER BY OIL AND OTHER HAZARDOUS SUBSTANCES, The Secretary of the Interior and The Secretary of Transportation, 1967.

This report is the result of a special study requested by the President to determine how the resources of the nation could better cope with oil pollution problems and with other pollutants and hazardous substances. The findings include:

1. Identification of the major sources of danger.
2. An assessment of the existing resources, legal authorities, and capabilities to attack this problem.
3. A recommended action program to set forth the administrative and legislative steps needed to deal with the problems of oil and other pollution control.

*WATER POLLUTION, *OIL, *FEDERAL GOVERNMENT, *LEGISLATION, *WATER POLLUTION CONTROL, harbors, control

359. "REPORT ON WATER QUALITY CRITERIA FOR TEXAS", in CLEAN WATER FOR THE NATION'S ESTUARIES, Transcript of Public Meeting, Biloxi, Mississippi, January 17, 1968, p. 6. Federal Water Pollution Control Administration, Department of the Interior, S.E. Region, Atlanta, Georgia.

It was pointed out that the proposed water temperature standard ("not more than a 2 C increase in ambient temperature at 100 yards from point of discharge") could result in curtailment of the operation of electric power plants as well as other industrial plants using water for cooling purposes and would seriously restrict the future development of electric power in Texas. It was also stated that there is no evidence that the present use of the waters of Texas for cooling purposes has been harmful in any way to other uses of the water including its use for fish and wildlife and for recreation.

*WATER QUALITY, *TEXAS, *WATER UTILIZATION, *ELECTRIC POWERPLANTS, cooling water, water temperature, heated water, engineering structures, structures, industrial plants, temperature, fish, water types, animals, aquatic animals, aquatic life, wildlife, thermal pollution, central U. S., coastal plains, geographical regions, Gulf coastal plain, regions, southwest U.S., efficiencies, powerplants, water pollution, water properties

360. REVIEW REPORT ON JAMES RIVER, VIRGINIA, U. S. Army Engineer District, Norfolk, Corps of Engineers, Norfolk, Virginia, 2 Volumes, January, 1962.

The purpose of this survey report is to determine the need and justification for the further improvement of James River from its mouth at Hampton Roads to the deep water terminal at Richmond, Virginia, a nautical distance of 86.4 miles. The study has included hydrographic surveys of those sections of the river where natural depths are less than 37 feet; topographic surveys of lands to be cut away in widening the existing channel; outlines of prospective shore areas for disposal of dredged material; planning of channel improvements and estimates of quantities, and costs therefore; and complete economic data to determine savings and benefits to accrue to existing and potential shipping. Two plans for further improvement of the channel are presented. The detailed design and cost estimates for channel improvements and a report on the considered navigation channel improvements in relation to fish and wildlife resources of James River are given in Volume 2.

*RIVERS, *CHANNEL IMPROVEMENT, *VIRGINIA, *COST-BENEFIT ANALYSIS, aquatic life, aquatic animals, waste disposal, transportation, harbors, benefits, fish, wildlife, animals, costs, surveys, bodies of water, running waters, streams, surface waters, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, regions, southeast U.S.

361. Richards, C. E., A SURVEY OF SALT-WATER SPORT FISHING IN VIRGINIA 1955-1960, Chesapeake Science, Vol. 3, No. 4, December, 1962, pp. 223-235.

A survey of sport fishing in a 1500 square mile area within the Virginia portion of Chesapeake Bay and its tributaries was made from mid-April through October to gain knowledge of the fishery and its relation to commercial landings. Effort estimates were based on daily boat-counts from a bridge overlooking the York River check area and aerial boat-counts from flights over the entire survey area. Voluntary catch records and interviews were the sources of catch-rate information. Logbook records were generally different from interview records and set catch-rates at a significantly higher level in the areas where both methods were used.

Reported sport catches of the four most improtant commercial food fishes amounted to a low of approximately 8.1 percent in 1955 to a high of 27.2 percent in 1951, of the total catch. The decline of croaker in the catch was severe: 2.2 fish per man-hour in 1955 to 0.2 per man-hour in 1960. A decrease in catch rates of croaker as the number of fishermen aboard party boats increased was noted. Spot catches increased and became the most abundant fish in the fisherman's creel during 1959 and 1960: 1.5 and 2.6 fish per man-hour of fishing.

They were also the most abundant fish for 1958, but at a catch rate of 0.8 fish per man-hour. Weakfish or gray sea trout declined from 0.7 fish per man-hour in 1955 to 0.2 fish per man-hour of fishing during 1960. The observed increases in availability of striped bass, puffer, and flounder compared to the declining availability of other fishes is interesting although there may be no connection between these stocks.

*SPORT FISHING, *MARINE FISH, *CREEL CENSUS, *VIRGINIA, *STATISTICS, commercial fish, striped bass, surveys, fishing, recreation, water sports, census, animals, aquatic animals, aquatic life, fish, wildlife, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, regions, southeast U. S., marine animals, saline water fish, data collections

362. Richardson, Marie S., BIBLIOGRAPHY ON AIR AND WATER POLLUTION, Special Libraries, July-August, 1966, pp. 385-390.

This bibliography includes literature references as well as originating sources of information on air and water pollution.

*WATER POLLUTION, *BIBLIOGRAPHIES, *AIR POLLUTION

363. Rogers, George W., THE FUTURE OF ALASKA, 1962. Johns Hopkins Press, Baltimore, Maryland.

Alaska is divided into three major areas, the north-central being the area of interest to the estuary study.

The economy of this area has been for some years in a transistory state, due to seasonal labor, rugged weather conditions, and remoteness from markets.

Once the principal occupation of the Cook Inlet and Prince William Sound was salmon fishing, but in recent years salmon fishing has declined drastically. More recent emphasis has been on the natural gas and petroleum industries and on defense. The discovery of major oil and gas deposits in the Cook Inlet region has touched off a boom in private oil exploration and development.

Knowledge of the physical characteristics of Alaska's tidelands is meager, and coastal and beach erosion are causing serious losses of land and property in some areas.

In general, resources in Cook Inlet and Prince William Sound have been sporadically and exhaustively exploited and abandoned. There have been little "colonization and conservation" efforts, and this remains a problem today.

Shipping is limited, since the markets are far away, and there has seemed to be a general trend towards air transport.

*COMMERCIAL FISHING, *ECONOMIC LIFE, *ALASKA, *INDUSTRIES, transportation, navigation, community development, geographical regions, Pacific coast region, regions, fishing, oil industry, erosion, beach erosion

364. Rogers, Leslie C., WORLD OFFSHORE RIG FLEET TO BALLOON AGAIN IN 1968, Oil and Gas Journal, Vol. 66, No. 1, January 1, 1968, pp. 29-30.

The author discusses future expansion of offshore oil rig construction. Also, the author tabulates present oil rig construction around the world and present idle rigs in the Gulf Coast.

*OIL INDUSTRY, *DRILLING, *OFFSHORE PLATFORMS, industries, engineering structures, hydraulic structures, structures, exploration, Gulf of Mexico, bodies of water, gulfs, surface waters, forecasting

365. Roper, Harry McK., Jr., "THE ROLE OF THE PHYSICAL HYDRAULIC MODEL OF SAN FRANCISCO BAY AND DELTA IN POLLUTION STUDIES", in PROCEEDINGS OF THE NATIONAL SYMPOSIUM ON ESTUARINE POLLUTION, August 23-25, 1967, pp. 423-440. Department of Civil Engineering, Stanford University, Stanford, California.

The use of a physical hydraulic model developed by the Corps of Engineers for studying pollution in San Francisco Bay is discussed. The model is constructed to a horizontal scale of 1:1,000 and a vertical scale of 1:100 and occupies an area of about two acres.

*HYDRAULIC MODELS, *WATER PLLUTION, *BAYS, *CALIFORNIA, model studies, bodies of water, geographical regions, Pacific coast region, regions, southwest U. S. deltas

366. Rorholm, Niels, ECONOMIC IMPACT OF NARRAGANSETT BAY, University of Rhode Island, Agricultural Experiment Station, Kingston, Rhode Island, Bulletin No. 374, December, 1963.

This study presents estimates of the annual "monetary impact" of the following activities associated with Narragansett Bay: naval installations, general summer sales, ship and boat building, fish landings (commercial), boatyards and marinas, transportation (bridge and ferry only), real estate taxes (on seasonal dwellings), research, and municipal expenditures. It is estimated that these impacts total not less than $145 million per year, of which $132 million is accounted for by naval installation payrolls. The value of the bay in the function of waste disposal is noted. The development of the estimates is explained, as well as their limitations and the importance of conflicts. Management policy recommendations are made for each level of government. Conflicts in use are classified in three types: I--physical space conflicts over a long period, II--physical space conflicts over a short period, and III--conflicts where one use creates a nuisance in relation to another use. It is argued that the best management policy is to increase all uses until conflicts occur, and then make subsequent use decision on the basis of cost-benefit analysis.

*ECONOMIC IMPACT, *BAYS, *RHODE ISLAND, *COMPETING USES, *COST-BENEFIT ANALYSIS, commercial fishing, military aspects, navigation, transportation, recreation, boats, marinas, taxes, government finance, fishing, industries, recreation facilities, bodies of water, geographical regions, regions, New England, northeast U.S., value, management, efficiencies, water utilization

367. Rorholm, Niels, H. C. Lampe, Nelson Marshall, and J. F. Farrell, ECONOMIC IMPACT OF MARINE-ORIENTED ACTIVITIES--A STUDY OF THE SOUTHERN NEW ENGLAND MARINE REGION, University of Rhode Island, Agricultural Experiment Station, Department of Food and Resource Economics, Kingston, Rhode Island, Bulletin No. 396, 1967.

The primary purpose of this report is to analyze the economic impact of those commercial enterprises that depend upon the near-ocean and the near-shore environment for their existence in given locations. The Southern New England Marine Region was selected as the study area. Chapter I describes the framework within which the marine industries operate. Chapters II and III deal with the marine industries themselves, first by way of description and subsequently in an input-output framework to facilitate a comprehensive economic impact evaluation. Chapter IV brings into consideration certain non-economic variables, and in Chapter V is discussed the growth of marine industries and the possible application of this work to other regions.

*ECONOMIC IMPACT, *ESTUARINE ENVIRONMENT, *INDUSTRIES, *NEW ENGLAND, geographical regions, regions, northeast U.S.

368. Rosen, A. A., L. R. Musgrave, and J. J. Lichtenberg, "CHARACTERIZATION OF COASTAL OIL POLLUTION BY SUBMARINE SEEPS", in PROCEEDING OF THE FIRST INTERNATIONAL CONFERENCE ON WASTE DISPOSAL IN THE MARINE ENVIRONMENT, July 22-25, 1959, pp. 353-371. Pergamon Press, New York.

Oil pollutants are identified, classified, and characterized. Oil emitted by submarine seeps is found to be different from other oil pollutants.

*WATER POLLUTION SOURCES, *OIL WASTES, *POLLUTANT IDENTIFICATION, *UNDERSEEPAGE, seashores, leakage, coasts, shores, organic matter, wastes, subsurface drainage, seepage, submarines, ships

369. Rosenberger, Richard L., and Raymond Walsh, "ESTUARINE WATER QUALITY MANAGEMENT IN THE SACREMENTO-SAN JOAQUIN DELTA", in PROCEEDINGS OF THE NATIONAL SYMPOSIUM ON ESTUARINE POLLUTION, August 23-25, 1967. Department of Civil Engineering, Stanford University, Stanford, California.

The San Francisco Bay-Delta Water Quality Control Program, which is a three-year study to develop a comprehensive plan for water quality control in the San Francisco Bay-Sacramento-San Joaquin Delta area of California, is summarized in this paper. Vast water development projects which would ultimately result in the complete control of inflow to the Delta and Bay are discussed. The Program's total study area covers nearly 40 percent of the state.

*LEGISLATION, *WATER QUALITY CONTROL, *CALIFORNIA, *PLANNING, long-term planning, economic impact, salinity, mathematical models, bays, deltas, southwest U. S., regions, Pacific coast region, geographical regions, control, quality control, mathematical studies, model studies, water pollution, chemical properties, water properties, bodies of water

370. Rothfuss, Edwin L., BENEATH THE SURFACE, Parks and Recreation, September, 1966, pp. 715-716, 810.

Two areas in the U.S. Virgin Islands, Virgin Islands National Park and Buck Island Reef National Monument, administered by the National Park Service, have become known as "underwater parks". They exhibit outstanding gardens, marine life, and seascapes and have become very popular snorkeling and skin diving areas. Scheduled underwater trips are led by a park naturalist. In 1965, a total of 793 persons were led on 73 organized trips. By September, 1966, there was already a 72 percent attendance increase over 1965.

At Buck Island approximately 85 percent of the 15,461 visits to the monument last year were underwater trail uses.

In Virgin Islands National Park, 1965 visitation of 57,000 showed a 17.6 percent increase by September, 1966.

Scuba diving, snorkeling, and underwater photography are becoming important water recreation activities.

*NATIONAL PARKS, *VIRGIN ISLANDS, *RECREATION, *WATER SPORTS, *STATISTICS, scuba diving, natural resources, scenery, federal reservations, parks, geographical regions, islands, regions, swimming, data collections, underwater, resources

371. Rounsefell, G. A., PRECONSTRUCTION STUDY OF THE FISHERIES OF THE ESTUARINE AREAS TRAVERSED BY THE MISSISSIPPI RIVER-GULF OUTLET PROJECT, Fishery Bulletin, U. S. Fish and Wildlife Service, Vol. 63, No. 2, 1964, pp. 373-393.

The author speculates that the construction of the deep water navigation channel from New Orleans to the Gulf of Mexico would cause a rise in salinity that could adversely affect the commercial blue crab and oyster populations. Blue crab larvae spend time in low saline marsh areas, while the higher salinities on the oyster beds may permit the intrusion of the oyster drill, a serious predator.

*CONSTRUCTION, *CHANNELS, *MISSISSIPPI RIVER, *LOUISIANA, *COMMERCIAL SHELLFISH, saline water systems, salt marshes, Gulf of Mexico, estuarine fisheries, oysters, commercial fishing, crabs, coastal plains, geographical regions, Gulf coastal plain, regions, southeast U.S., fishing, industries, bodies of water, interstate rivers, rivers, running waters, streams, surface waters, marshes, wetlands, gulfs, animals, aquatic animals, aquatic life, invertebrates, shellfish

372. Rounsefell, G. A., REALISM IN THE MANAGEMENT OF ESTUARIES, No. 1, December, 1963. Alabama Marine Resources Laboratory, Dauphin Island, Alabama.

The author maintains that estuaries are vital because they are nursery areas for many species. He feels that the productivity of estuaries is being endangered by unrealistic recommendations that do not deal with the entire estuarine system. Some interesting statistics derived from other sources are quoted as are the findings of a number of biological studies illustrating the complexities of estuarine systems.

*MANAGEMENT, *FISH MANAGEMENT, *ECOLOGY, food chains, fisheries, statistics, data collections, estuarine fisheries, biological communities

373. Rowan, P. P., K. C. Jenkins, and D. H. Howells, ESTIMATING SEWAGE TREATMENT PLANT OPERATION AND MAINTENANCE COSTS, Water Pollution Control Federation, Journal, Vol. 33, No. 2, February, 1961, pp. 111-121.

Cost data presented in this report represent total annual cost experience for the operation and maintenance of over 300 treatment plants in the contiguous 48 states plus the District of Columbia.

*SEWAGE TREATMENT, *OPERATION AND MAINTENANCE, *OPERATING COSTS, *TREATMENT FACILITIES *ESTIMATING, costs, waste treatment

374. RULES ON VESSEL POLLUTION PROPOSED BY SENATOR MUSKIE, Traffic World, Vol. 132, No. 3, October 21, 1967, p. 101.

This is a news item describing a bill to regulate discharge of wastes from vessels in United States waters.

*WATER POLLUTION CONTROL, *LEGISLATION, *SHIPS, navigation, water pollution sources

375. Ryan, J. Donald, THE SEDIMENTS OF CHESAPEAKE BAY, State of Maryland, Board of Natural Resources, Department of Geology, Mines and Water Resources, Bulletin No. 12, 1963.

The results of research to determine the physical characteristics and origins of Chesapeake Bay sediments are reported. Methods of study and descriptions of samples, geologic and physiographic characteristics, hydrographic considerations, erosion rates and sources, oyster distribution, and mineralogy of the sediments are discussed. Maps of sediments are shown. The objective of the study was, "to determine the mechanism of siltation in Chesapeake Bay", and did not include study of the effects of siltation upon oyster production. However, the report states "...the oyster beds are restricted to the sandy areas of the bay bottom where silt and clay are practically absent. Most of the large areas of sand bottom within the bay include extensive areas where oysters breed.... the absence of oyster bars in channel muds is probably due more to the poor environment than to the silt and clay-size particles. Similar toxic conditions are not present in the favored areas of shallow water and sand bottom. It does not seem likely, therefore, that a mere increase in quantity of the fine material in suspension would have much of an adverse effect on the oyster crop. Rapid encroachment of mud over oyster bars might cause gradual readjustment in the location of the bars, but no such encroachment was observed in this investigation."

*SEDIMENTATION, *SEDIMENTS, *OYSTERS, *MARYLAND, sedimentation rates, sediment distribution, rates, animals, aquatic animals, aquatic life, benthic fauna, benthos, commercial shellfish, invertebrates, marine animals, mollusks, shellfish, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, regions, northeast U.S., bays, bodies of water

376. Saback, David K., PRODUCERS' MARGINS FOR FOOD FISH AND SHELLFISH, Bureau of Commercial Fisheries, Circular 156, November, 1962.

This acticle discusses the principal factors affecting producers' (fishermen) margins, defined as the protion he receives of the retail price paid by the consumer and expressed in this report as a percentage of the retail price. The author discusses trends in these margins from around 1947 through 1960. Although the percentages vary, the trends are quite significant. The total amount of fisheries products and the various steps undergone by the product, e.g. costs of packaging plants and equipment, storage facilities, and transportation are discussed as factors affecting producers' margins.

Also discussed are factors affecting the producers' margins for specific fisheries products. Tables and graphs are included which show trends in margins for particular species.

*COMMERCIAL FISHING, *COMMERCIAL SHELLFISH, *MARKETING, *GROSS PROFIT, *INDIRECT COSTS, fish harvest, profit, net profit, appreciation, market value, economics, competitive prices, fishing, industries, fisheries, animals, aquatic animals, aquatic life, invertebrates, shellfish, value, costs, prices

377. Saila, S. B., T. T. Polgar, and B. A. Rogers, RESULTS OF STUDIES RELATED TO DREDGED SEDIMENT DUMPING IN RHODE ISLAND SOUND, Graduate School of Oceanography, University of Rhode Island, Kingston, Rhode Island.

An area one nautical mile square (Latitude 41°23'25" and Longitude 71°17'58") was examined to obtain information on: (1) site conditions prior to disposal, (2) observations during actual dumping operations, and (3) effects of dredged material on economically important marine resources in its vicinity. Results of observations and experiments were analyzed, and it was concluded that the site studied was acceptable from the point of view of minimizing damage to locally important marine resources.

*DREDGING, *MARINE ANIMALS, *RHODE ISLAND, *WATER POLLUTION EFFECTS, sediments control, control, animals, aquatic animals, aquatic life, geographical regions, New England, northeast U. S., regions

378. SALINE WATER CONVERSION REPORT, Office of Saline Water, Department of the Interior, 1966.

This report is made annually by the Department of the Interior to the President as required by Public Law 448, 82nd Congress, 2nd session. The report summarizes the program and accomplishments of the Office of Saline Water with emphasis on work completed in the preceding year.

Among some of the research results mentioned are the following:

1. A dual-purpose nuclear power and water plant producing 150 million gallons/day of water and 1800 megawatts of electricity was studied in relation to feasibility for construction and operation off-shore of Orange County, California.

2. The possibility of using desalting as an alternative source of water in the northeast during drought periods was examined. The results indicated that fresh water supply from the Hudson River currently provides the most economic interim source, but that desalting may offer advantages in the future.

3. A study of saline-water conversion in relation to 37 Texas cities revealed that saline-conversion costs were equal to or less than conventional water supplies in 11 instances and more expensive in 27.9 cities in the lower Rio Grande valley. The 11 instances represent a special case for future study because their needs might be supplied by one or more large-scale desalting plants.

*DESALINATION, *COSTS, *WATER SOURCES, *FEDERAL GOVERNMENT, *WATER SUPPLY, saline water, demineralization, separation techniques, water purification, water treatment, desalination plants, water types, nuclear powerplants, electric powerplants, engineering structures, industrial plants, powerplants, structures, California, geographical regions, Pacific coast region, regions, southwest U. S., Hudson River, bodies of water, rivers, running waters, streams, surface waters, Texas central U. S., coastal plains, Gulf coastal plains, Rio Grande, interstate rivers

379. SAVING OUR ESTUARIES, Ocean Industry, Vol. 2, No. 10, October, 1967, pp. 3-4.

This article discusses steps being taken by the Federal Water Pollution Control Administration regarding estuaries.

*WATER POLLUTION CONTROL, water pollution, control, water quality control, quality control

380. Schelake, Claire L., and Eugene P. Odum, "MECHANISMS MAINTAINING HIGH PRODUCTIVITY IN GEORGIA ESTUARIES", in CLEAN WATER FOR THE NATION'S ESTUARIES, Proceedings of the Georgia Public Meeting, Jekyll Island, Georgia, November 29, 1968, pp. 75-80. Federal Water Pollution Control Administration, Department of the Interior, S. E. Region, Atlanta, Georgia.

The results of studies of the extensive, unpolluted estuaries at Sapelo Island, Georgia, indicate that the following factors are responsible for high productivity: (1) ebb and flow water movements resulting from tidal action, (2) abundant supplies of nutrients, (3) rapid regeneration and conservation of nutrients due to activity of microorganisms and filter feeders, (4) three types of primary production units (harsh grass, benthic algae, and phytoplankton), which insure maximum utilization of light at all seasons, and (5) year-round production with successive crops. These factors are discussed and illustrated by data obtained by various workers at the University of Georgia Marine Institute, Sapelo Island.

*GEORGIA, *PRODUCTIVITY, nutrients, tides, photosynthesis, Appalachian Moutain region, Atlantic coastal plain, coastal plains, geographical regions, regions, southeast U. S., aquatic life, tidal effects, data collections

381. Schmidt, Ralph A., NEEDED--A COASTWISE COMPREHENSIVE PROGRAM FOR DEVELOPMENT OF ESTUARIES, A Symposium on Estuarine Fisheries, American Fisheries Society, Special Publication No. 3, 1966, pp. 102-109.

The author presents estimates of average annual weight and value of commercial finfish and shellfish landings during the 1952-61 period for the North Atlantic Coast (Delaware to Maine), and the share of total U. S. landings these accounted for. Results of the Fish and Wildlife Service recommendations in the case of permit requests for dredging, land reclamation, etc., in the New York City-Long Island area and the New England area are discussed. The author points out that many permits have been granted contrary to recommendations may by the Fish and Wildlife Service. Estimates of physical loss of tidal marsh area from Maine to Delaware during the 1954-59 period (23,500 acres) and during the 1959-65 period (21,500 acres) are given. A breakdown by end-use of marsh area lost is also given. Legislation relating to tidelands preservation in North Atlantic Coastal States is discussed.

*ESTUARINE FISHERIES, *TIDAL MARSHES, *DREDGING, *PERMITS, *WATER MANAGEMENT, programs, planning, legal aspects, land reclamation, commercial fishing, sport fishing, northeast U. S., fishing, industries, recreation, water sports, fisheries, marshes, wetlands, legal aspects, legislation, northeast U. S., Atlantic coastal plain, geographical regions, regions, management

382. Scott, John, WHAT'S AHEAD IN OIL RECOVERY, Petroleum Engineer, Vol. 39, November, 1967, pp. 61-64.

Total oil in-place figures are presented in comparison with a past recovery percentage of 15 percent (1930), a present percentage of 30 percent (1967), and a future recovery percentage of 40 percent (1987). Tables show past, present, and future (1980) figures of primary versus secondary recovery totals. Present and future secondary oil recovery techniques are also examined.

*OIL RESERVOIRS, *SECONDARY RECOVERY (OIL), *OIL INDUSTRY, flooding, injection, oil, methodology, planning, industries

383. SEAFARING EMPLOYMENT, Division of Labor Studies, Office of Maritime Manpower, Washington, D. C., February 20, 1967.

This is a table showing the number of jobs, by type of ship, aboard ocean-going U. S. flag merchant ships of 1000 gross tons or over from 1947.

*MANPOWER, *SHIPS, transportation

384. THE SEAFOOD INDUSTRY, A LOCAL ANALYSIS, City Planning Commission, Hampton, Virginia, November, 1967.

The seafood industry of Hampton, Virginia, is compared by percentages with the industry (1) in the Chesapeake Bay area, (2) on the East Coast, and (3) in the United States. Tables indicating the volume and value of the various following components in the industry are given: (1) seafood production volume, (2) value of industry, (3) employment data, and (4) seafood landings volume.

*VIRGINIA, *COMMERCIAL FISHING, *COMMERCIAL SHELLFISH, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, regions, southeast U. S., employment, shellfish, animals, aquatic animals, aquatic life, invertebrates

385. Sears, Howard J., "STATEMENT", in CLEAN WATER FOR THE NATION'S ESTUARIES, Proceedings of the Georgia Public Meeting, Jekyll Island, Georgia, February 29, 1968, pp. 43-45. Federal Water Pollution Control Administration, Department of the Interior, S. E. Region, Atlanta, Georgia.

There are more than 95,000 acres of estuarine area within Glynn County, Georgia. These acres are important nursery grounds and habitats for shellfish, which provide an annual catch of 100 million pounds. The local seafood processing industry employs 1/3 of the area's manufacturing workers, including 85 percent of the local females employed in manufacturing. This industry as well as the estuarine-oriented recreation industry is being threatened by pollution.

*FISH HANDLING FACILITIES, *COMMERCIAL SHELLFISH, *GEORGIA, *ECONOMIC IMPACT, environment, habitats, facilities, outdoor recreation, labor, water pollution, employment, recreation, facilities water pollution effects, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, regions, southeast U. S., animals, aquatic animals, aquatic life, invertebrates, shellfish

386. Seckler, David N., ON THE USES AND ABUSES OF ECONOMIC SCIENCE IN EVALUATING PUBLIC OUTDOOR RECREATION, Land Economics, Vol. XLII, No. 4, November, 1966, pp. 485-494.

Three theoretical techniques are commonly used in connection with statistical demand curves for recreation. They are:

1. Computation of benefits attributable to a recreation project as the area under the demand curve, and comparing with total project costs.
2. Defining optimum price and usage as the point where Marginal Cost = Marginal Utility, producing a maximum B-C ratio.
3. Using demand curve to compute maximum revenue available from a recreation facility.

The author criticizes demand curves in general, arguing that they do not measure the utility function of recreation facilities, but reflect the diminishing marginal utility of income. He criticizes procedures to allocate recreation usage by market processes and point to the bias inherent in these methods towards higher income users of recreation.

The author proposes that demand curves be corrected for effects of unequal income distribution and that corrected demand curves be applied to Technique 2 for evaluation of recreation facilities. He further proposes that real prices implicit in this evaluation not be used in actuality unless recreation is to be limited to the wealthy.

*RECREATION DEMAND, *COST-BENEFIT RATIO, recreation, benefits, demand, social aspects

387. Shaw, William N., ADVANCES IN THE OFF-BOTTOM CULTURE OF OYSTERS, Gulf and Caribbean Fisheries Institute, 19th Annual Session, Proceedings, September, 1967, pp. 108-115.

The author gives a review of the research in off-bottom culture of oysters. He feels that the present decline in the oyster industry along the East Coast can only be offset by such techniques, and that one of the most significant reasons for a failing industry in the Chesapeake Bay region is the lack of private farming. It is also stated that the difficulty of obtaining exclusive use of oyster lands in the Maryland portion of the Chesapeake has prevented the development of private oyster farming.

*OYSTERS, *FISH FARMING, *CULTURAL CONTROL, *PRODUCTIVITY, commercial shellfish, animals, aquatic animals, aquatic life, benthic fauna, benthic fauna, benthos, invertebrates, marine animals, mollusks, shellfish, agriculture, control, Maryland, Virginia, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions, southeast U. S., bays, bodies of water

388. SHORELINE RECREATION RESOURCES OF THE UNITED STATES, George Washington University for the Outdoor Recreation Resources Review Commission (ORRRC), Report No. 4, 1962.

The report inventories existing coastal recreation facilities. Accessibility and availability are characterized as the two important recreation area targets. Shoreline areas are considered highly accessible if they are within 30 miles, or one hour driving time, of a metropolitan area of 500,000 or more.

Recreation shoreline is defined as: (1) having a marine climate and environment, (2) having an expanse of view over water of at least five miles, and (3) being located on a water boundary. This definition excludes many estuarine shoreline recreation sites. Inventories of shoreline recreation areas are designated by coast, state, type (beach, bluff, or marsh), ownership, and degree of development.

Appendix B discusses, by state, general features of shoreline recreation areas, administration, water pollution control, erosion control, tidelands ownership and access, and the status of recreation planning.

*RECREATION FACILITIES, *WATER POLLUTION CONTROL, *EROSION CONTROL, *SHORES, beaches, parks, control

389. Shuster, C. N., Jr., A BIOLOGICAL EVALUATION OF THE DELAWARE RIVER ESTUARY, Information Series Publication No. 3, University of Delaware Marine Laboratories, Newark, Delaware, 1959.

This report deals with biological productivity in the Delaware River Estuary. Sections are devoted to the morphometry and extent of the estuary, the role of tidemarshes in estuarine production, shore zone fishes, comments on the ecology of estuarine invertebrates and evaluation of the estuarine fisheries, a hypothesis on tidemarsh productivity, and a section of concluding remarks concerning the relative value of the Delaware estuary.

The section on the evaluation of the estuarine fisheries is a summary report to 1959 on the dollar value of the fisheries crops harvested from the estuary and of the fisheries based upon these crops, including the sport fishery. Figures are given for the oyster, hard clam, and blue crab fisheries, in addition to the fin fisheries. A limited estimate of values pertaining to the sport fishing industry in Delaware Bay is also provided.

*DELAWARE RIVER, *ECOLOGY, *MONETARY BENEFITS, *ESTUARINE FISHERIES, *FISH HARVEST, evaluation, commercial fishing, bodies of water, interstate rivers, rivers, running waters, streams, surface waters, profit, benefits, fishing, industries, fisheries, sport fishing, recreation, water sports, shellfish, animals, aquatic life, tidal marshes, marshes, wetlands

390. Simmons, Henry B., "APPLICATIONS AND LIMITATIONS OF ESTUARY MODELS IN POLLUTION ANALYSIS", in PROCEEDING OF THE FIRST INTERNATIONAL CONFERENCE ON WASTE DISPOSAL IN THE MARINE ENVIRONMENT, July 22-25, 1959, pp. 540-546. Pergamon Press, New York.

Estuary models can reproduce surprisingly accurate conditions of velocity and salinity of the estuary studied. Methylene blue chlorid, which is used as a tracer for the simulation of wastes, can pinpoint pollution concentrations in the model. Models are not capable of providing all of the necessary answers, but they are capable of accurate integration of the tidal, density, and fresh water forces which effect the dispersion, dilution, and flushing of wastes. A model of the Delaware Estuary is described.

*WASTES, *VELOCITY, *MODEL STUDIES, *DELAWARE RIVER, *ANALYTICAL TECHNIQUES, *SALINITY, waste dilution, waste disposal, rates, diffusion, currents (water), water pollution, effluents, bodies of water, interstate rivers, rivers, tracking techniques, mathematical models, chemical properties, water properties, tracers, dye releases, path of pollutants, running waters, streams, surface waters, dispersion

391. Singewald, Joseph T., Jr., and Turbit H. Slaughter, SHORE EROSION IN TIDEWATER MARYLAND, Bulletin 6, 1949. Maryland Board of Natural Resources, Department of Geology, Mines, and Water Resources.

This book provides measurements of shore erosion by county in Maryland. It discusses the kinds of damage which has occurred, measures taken to arrest the problem in Maryland, and gives examples of shore erosion problems in other areas of the country.

*BEACH EROSION, *MARYLAND, *SHORE PROTECTION, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, regions, northeast U.S., statistics, data collections

392. Slease, Clyde H., TESTIMONY - NATIONAL SAND AND GRAVEL ASSOCIATION, Estuarine Hearings, Subcommittee on Fisheries and Wildlife Conservation of the Committee on Merchant Marine and Fisheries, House of Representatives, 90th Congress, Serial No. 90-3, March, 1967.

During the 30-year period, 1962-92, an estimated 42 billion tons of sand and gravel will be produced. Presently held reserves will be exhausted in about 20 years. Approximately 10 percent of production is from waterways, and most of this is estuarine. The author does not believe that sand and gravel dredging is incompatible with fish and wildlife interests and opposes the bill before Congress because he fears that dredging interests will be restricted.

*SANDS, *DREDGING, *GRAVELS, *ESTUARINE ENVIRONMENT, *FORECASTING, construction materials, earth materials, pervious soils, soil types, aquatic environment, environment

393. Smith, Austin B., "CHANNEL SEDIMENTATION AND DREDGING PROBLEMS, MISSISSIPPI RIVER AND LOUISIANA GULF COAST ACCESS CHANNELS", in PROCEEDINGS OF THE INTER-AGENCY SEDIMENTATION CONFERENCE, 1963, Miscellaneous Publication No. 970, June, 1965, pp. 618-626. Department of Agriculture, Washington, D. C.

Sedimentation has always been a major navigational problem at the Mississippi River passes. This is being constantly remedied by construction of retention dikes, jetties, and channelization. The quantity of sediment removed and some removal costs are indicated for certain river stretches.

Sediment loads of 1,000,000 tons daily are brought to the Mississippi River mouth, extending the channel profile 100 feet per year. It is anticipated that extensive maintenance dredging will be required in the new Mississippi Gulf Outlet.

*SEDIMENTATION, *DREDGING, *MISSISSIPPI RIVER, *LOUISIANA, coastal plains, geographical regions, Gulf coastal plain, regions, southeast U.S., channels, jetties, structures, hydraulic structures, engineering structures, embankments, sediment transport, bodies of water, interstate rivers, rivers, running waters, streams, surface waters, navigable waters, dikes, channel improvement, earthworks

394. Sobel, Matthew J., WATER QUALITY IMPROVEMENT PROGRAMMING PROBLEMS, Water Resources Research, Vol. 1, No. 3, 1965, pp. 477-487.

In recent years, the rate of investment in facilities for water-quality control has increased, and the need to program water-resources use on a regional basis has been recognized. This paper outlines the nature of regional water-quality systems and presents programming models for several water-quality improvement problems. A linear programming formulation of a static improvement in quality is contrasted with a traditional policy for programming improvements; the traditional policy results in a mixed-integer problem. The maximization of the ratio of benefits to costs of an improvement program is transformed to a linear programming problem. A stochastic natural environment leads to other programming models. The application of least-cost models is also discussed.

*MATHEMATICAL MODELS, *WATER QUALITY CONTROL, *COST-BENEFIT RATIO, *WATER TREATMENT, systems analysis, model studies, mathematical studies, control, quality control, regional analysis, cost

395. SPORT FISHING--TODAY AND TOMORROW, Bureau of Sport Fisheries and Wildlife, Department of the Interior, Washington, D. C.

Estimates of sport fishing as related to population growth indicate that by the year 2000, 63 million anglers will fish 1,300,000,000 days.

Understandably, conservationists are wondering whether the current water supply can withstand the strain. The increase in fishing demand can be met with only slight reductions in the average catch by: (1) adding new waters, mostly farm ponds; (2) better management of existing waters; and (3) more fishing in coastal waters and estuaries.

Statistics are given from the 1960 National Survey of Fishing and Hunting for number of fisherman days, days per angler, and average catch per state. Availability and access to marine waters is presented as well as the list of state agencies managing marine sport fisheries and the miles of coastline in each state open to sport fishing. Special attention is given to the problems of estuarine pollution.

*SPORT FISHING, *STATISTICS, *WATER SUPPLY, *FORECASTING, recreation demand, social participation, recreation facilities, data collections, fishing, recreation, demand

396. Stansby, Maurice E., editor, INDUSTRIAL FISHERY TECHNOLOGY, 1963. Reinhold Publishing Corporation, New York.

Part I of this book concerns fish characteristics, conservation, statistical data on U. S. and world fisheries from about 1929 through 1959, and fisheries' harvesting methods.

Part II is a description of the major fisheries in the U. S. and specific descriptions of the fish species. The 16 most valuable commercial species are discussed in this section.

Part III deals with fisheries' by-products, specifically the production of oil and fish meal.

Part IV is a discussion of preservation methods employed by U. S. commercial fisheries.

Part V discusses the role of modern science as it relates to fisheries technology.

*FISHERIES, *COMMERCIAL FISHING, *FISH CONSERVATION, *FISH HARVEST, *FISH, commercial shellfish, fish handling facilities, fishing gear, Atlantic menhaden, salmon, oysters, clams, herrings, marketing, mollusks, salmonids, statistics, preservation, equipment, fish types, fishing, industries, animals, aquatic animals, aquatic life, invertebrates, shellfish, facilities, marine animals, marine fish, saline water fish, wildlife, benthic fauna, benthos

397. STATE AND LOCAL GOVERNMENT ACTIVITIES AND ROLES IN MARINE SCIENCE, ENGINEERING AND DEVELOPMENT. A BRIEFLY ANNOTATED CATALOG OF PUBLISHED STUDIES AND REPORTS ON SUCH ORGANIZATIONAL ARRANGEMENTS AND ACTIVITIES IN THE COASTAL STATES AND IN THOSE BORDERING ON THE GREAT LAKES, John I. Thompson and Company, Washington, D. C., PB 177764, February 14, 1968

The bibliography covers state and local administration of facilities and programs for marine activities in states on the seacoasts and bordering the Great Lakes. See also the basic report by Gilbert L. Maton, et al. (PB 177765).

*GREAT LAKES REGION, *COASTS, *GOVERNMENTS, *STATISTICS, *SURVEYS, geographical regions, regions, data collections

398. "STATEMENT", in CLEAN WATER FOR THE NATION'S ESTUARIES, Transcript of Public Meeting, Biloxi, Mississippi, January 17, 1968, p. 8. Federal Water Pollution Control Administration, Department of the Interior, S. E. Region, Atlanta, Georgia.

The Mississippi Power and Light Company contends that since it has found no change in aquatic life near discharge points of heated effluents, and since the dissipation of such effluents occurs almost immediately upon discharge into cooler waters, the cost of cooling towers is not justifiable. The evaporation of water which would occur at the Vicksburg plant, furthermore, would be in excess of 5.7 million gallons a day.

They state that cooling standards ("Temperature shall not be increased more than 10 F above the intake natural prevailing background temperature after reasonable mixing a discharge water with surrounding waters.") which are applied generally in Northern sections of the United States are not realistic for the Vicksburg, Mississippi, powerplant.

*MISSISSIPPI, *COOLING TOWERS, *WATER UTILIZATION, *THERMAL POLLUTION, *POWERPLANTS, aquatic populations, aquatic life, surface waters, streams, running waters, economic justification, water quality, standards, heated water, electric powerplants, engineering structures, industrial plants, bodies of water, interstate rivers, populations, rivers, Mississippi River, southeast U. S., regions, structures, water pollution, water cooling, cooling, coastal plains, geographical regions, Gulf coastal plain, water types

399. STEAM-ELECTRIC PLANT CONSTRUCTION COST AND ANNUAL PRODUCTION EXPENSES--1965, Federal Power Commission, 1966.

This report is primarily designed to provide data on steam-electric powerplant costs. It also provides a listing of the larger plants and their sources of condensing water. A complete listing of plants is available in the Federal Power Commission files.

*ELECTRIC POWERPLANTS, *STEAM TURBINES, *COST ANALYSIS, *CONSTRUCTION COSTS, powerplants, thermal powerplants, engineering structures, industrial plants, structures, equipment, turbines, analysis, mathematical studies, electric power, costs

400. Stevens, Joe B., RECREATION BENEFITS FROM WATER POLLUTION CONTROL, Water Resources Research, Vol. 2, No. 2, 1966, pp. 167-182.

A methodology for estimating direct recreational benefits from water pollution control was developed through a model of biological and behavioral relationships involved in sports angling. A biological production function was envisaged between inputs of angling effort and the output, or yield, of fish taken. The marginal product, angling success per unit of effort, was taken to represent the "quality" of the recreational experience. Water pollution would cause deteriorations in dissolved oxygen, temperature, or toxicity characteristics of the water, thus shifting the production function downward and causing reductions in angling success, angling effort, and recreational value of the fishery. Demand equations and "success-effort" elasticities were estimated for three estuarial sports fisheries, and the methodology was illustrated by means of an assumed reduction in angling success. The direct recreational benefits were identified as the consumer surplus that would result from the prevention of water pollution.

*BENEFITS, *RECREATION, *SPORT FISHING, *WATER POLLUTION CONTROL, *ESTIMATING, recreation demand, elasticity of demand, control, demand, toxicity, thermal pollution, water pollution, dissolved oxygen, water pollution effects, model studies, fishing, water sports

401. Stommel, Henry, COMPUTATION OF POLLUTION IN A VERTICALLY MIXED ESTUARY, Sewage and Industrial Wastes, Vol. 25, No. 9, September, 1953, pp. 1065-1071.

A model employing finite differences equations is presented for calculating the concentration of both conservative and non-conservative pollutants in a vertically unstratified estuary in which all mixing is due to tidal action. A brief numerical example is given, but is not particularly instructive due to limited discussion and interpretation of results.

*WASTE ASSIMILATIVE CAPACITY, *MATHEMATICAL MODELS, *MIXING, mathematical studies, model studies, water pollution, currents (water), tidal effects, tidal waters, tides

402. Stotts, V. D., USE OF OFFSHORE DUCK BLINDS BY NESTING WATERFOWL IN THE MARYLAND PORTION OF THE CHESAPEAKE BAY AND ITS ESTUARIES, Southeastern Association of Game and Fish Commissioners, 12th Annual Conference, Proceedings, 1958, pp. 1-7.

The author states that the continuing destruction of available nesting habitat by expanding industry and population is leading to a severe lack of nesting space. He feels that offshore duck blinds, unused during the nesting season, could make ideal nesting sites and offset the loss of space. Proper management and legislation is needed to make this idea effective.

Tables on trends in the numbers of duck blinds and hunters in the Chesapeake region are provided.

*WILDLIFE HABITATS, *WATERFOWL, *NESTING, *MARYLAND, *WILDLIFE CONSERVATION, estuarine environment, hunting, animals, aquatic life, birds, ducks (wild), migratory birds, wildlife, game birds, wildlife management, management, habitat improvement, legislation, small game, animal behavior, behavior, nests, aquatic environment, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U. D., regions, environment, habitats, conservation

403. Strandberg, Carl H., "REMOTE SENSOR SURVEILLANCE OF WATER QUALITY", in MARINE, ESTUARIAN, AND RIPARIAN POLLUTION DISASTERS AND THEIR CONSEQUENCES, Ocean Resources Subcommittee Meeting, December 12, 1967. National Security Industrial Association, Washington, D. C.

Urban centers so dependent on a centralized water supply need the security of an assured supply and quality level.

"Aerial remote sensors open many new avenues of approach for analysis of water quality. Many water quality degrading factors result in changes in water color, clarity, density, and viscosity. Aquatic population changes occur, and these may also change water color and clarity. Aerial photographs and imagery obtained using nonphotographic sensors can be used to record significant facts and events."

Using these methods, comprehensive surveillance of water supplies will be possible.

*WATER RESOURCES, *AERIAL PHOTOGRAPHY, remote sensing, photography, environmental effects, water quality control, resources, analytical techniques, data collections, quality control, control

404. Streeter, H. W., and E. B. Phelps, A STUDY OF POLLUTION AND NATURAL PURIFICATION OF OHIO RIVER, Public Health Service, Department of Health, Education and Welfare, Bulletin No. 146, February, 1925.

The report describes the working principles involving the organic stability of polluted streams. The basic mathematical equations which combine the deoxygenation constant, reaeration coefficient, oxygen deficit, temperature, dissolved oxygen, BOD, and other parameters are discussed. The general applicability of these equations in predicting the effect of pollution upon the self-purification of streams is confirmed with the experimental results carried out in various reaches of the Ohio River and its major tributaries.

*OHIO RIVER, *STABILITY, *WATER POLLUTION, *EQUATIONS, water purification, water treatment, oxygen demand, biochemical oxygen demand, dissolved oxygen, mathematical studies, oxygenation, reaeration, self-purification, temperature, water properties, water temperature, bodies of water, interstate rivers, rivers, running waters, streams, surface waters

405. Strobel, Gerald A., COLIFORM-FECAL COLIFORM BACTERIA IN TIDAL WATERS, Journal of the Sanitary Engineering Division, Vol. 94, No. SA4, August, 1968, pp. 641-656.

The fecal coliform-coliform relationship has been examined for several estuaries on Long Island to evaluate proposed fecal coliform standards for shellfish growing waters. The level of fecal coliforms to coliforms was found to vary with source of pollution, level of treatment provided, characteristics of the receiving waters, and precipation on the watershed. The data demonstrated that correlations for relating fecal coliform limits to present coliform standards must take into account the particular characteristics of each shellfish growing area. These correlations should be used until the level of public health hazard associated with the various standards is better determined and can be used to define new standards based on the public health significance associated with their use.

*COLIFORMS, *WATER POLLUTION, *SHELLFISH, *PUBLIC HEALTH, sanitary engineering, engineering, environmental engineering, animals, aquatic animals, bacteria, microorganisms, plants, breeding, Atlantic coastal plain, coastal plains, geographical regions, regions, aquatic life

406. Stroud, R. H., and P. A. Douglas, THERMAL POLLUTION OF WATER, SFI Bulletin, No. 191, January-February, 1968, pp. 1-8.

The authors define water pollution generally as impairment of water quality to a degree which has an adverse effect on beneficial use of the water. They feel that if the desired use of the water is not impaired, there is no pollution. They argue that limited or controlled thermal additions to water can be beneficial. Furthermore, they feel that increased legislation may be necessary to insure that thermal additions are controlled.

The effect of thermal pollution in estuaries is discussed.

*THERMAL POLLUTION, *WATER QUALITY CONTROL, *BENEFITS, *WATER POLLUTION EFFECTS, commercial fishing, water pollution, beneficial use, impaired water quality, water quality, heated water, legislation, control, quality control

407. Stroup, E. D., D. W. Pritchard, and J. H. Carpenter, FINAL REPORT ON BALTIMORE HARBOR STUDY, Chesapeake Bay Institute, The Johns Hopkins University, Baltimore, Maryland, Technical Report No. XXVI, December, 1961.

This final report describes an investigation which "concerned itself primarily with the physical description of the waters of Baltimore Harbor and the adjacent portion of Chesapeake Bay, the principal objective being the determination of the mechanisms which bring about flushing of the Harbor and the rate at which this flushing occurs".

The report contains a large collection of descriptive data. The authors conclude that "...the major result of the work can be simply stated: as a result of mechanisms which were not previously recognized, and which have not yet been reported for any other estuarine location, the flushing rate of Baltimore Harbor is substantially more rapid than had previously been estimated.

The mean life of the Harbor water, i.e., the average time which any particle of water within the Harbor at any instant may be expected to remain within the Harbor, has been found to be of the order of 10 days; previous estimates placed the mean life at from several times 10 to over 100 days."

*WASTE ASSIMILATIVE CAPACITY, *WATER QUALITY, *HARBORS, *MARYLAND, diffusion, circulation, acidic water, water types, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions, water pollution effects, water properties

408. A STUDY OF THE U . S. COAST AND GEODETIC SURVEY'S PRODUCTS AND SERVICES AS RELATED TO ECONOMIC ACTIVITY IN THE U. S. CONTINENTAL SHELF REGIONS, Battelle Memorial Institute, Technical Economics, Columbus, Ohio, January 17, 1966.

The services provided by the United States Coast and Geodetic Survey are evaluated in terms of influence and effect on economic activities in the United States Continental Shelf regions. Activities are broken down into ten major groups for the purpose of this study:

1. Mining and petroleum
2. Marine engineering
3. Recreation
4. Health and welfare
5. Transportation
6. Food and agriculture
7. Defense and space (U.S. Coast Guard included)
8. Research and development
9. Industry (not elsewhere classified)
10. State and local agencies.

Each category covers the economic activity within the group in the U. S. continental-shelf regions, the dependency of that activity upon U. S. Coast and Geodetic Survey products and services, and the uses of and present needs for additional U. S. Coast and Geodetic Survey products and services related to the U. S. continental-shelf regions.

Sub-categories within each category are discussed in four aspects:

1. Estimate of present economic activity
2. Estimate of worth of USCGS products and services
3. Description of user problems and needs
4. Estimate of future economic activity.

*SURVEYS, *CONTINENTAL SHELF, *ECONOMIC IMPACT, *FEDERAL GOVERNMENT, regions, continental margin, mining, mineral industry, exploration, drilling, offshore platforms, oil industry, civil engineering, coastal engineering, recreation, ships, tsunamis, saline water intrusion, water quality, transportation, commercial fishing, resource development, governments, generators, agriculture, military aspects, research and development, communication, electric generators, water resources development, industries, engineering structures, hydraulic structures, structures, engineering, public health, fishing, foods, electrical equipment, equipment

409. SUMMARY ECONOMIC BASE STUDY CHESAPEAKE BAY DRAINAGE BASINS, National Planning Association, Center for Economic Projections, Washington, D. C., Report No. 1409, February, 1967.

This report highlights the analyses and major qualitative results of the Chesapeake Bay Drainage Basin Study. The study is divided into 18 economic subregions for which individual economic profiles are given. Four of these subregions are relevant to the Chesapeake Bay estuary:

Subregion 8: Baltimore
Subregion 9: Peninsula (Maryland, E. Shore)
Subregion 13: Washington
Subregion 18: Norfolk.

Employment data and projections are given by subregions, as are manufacturing employment data and projections.

There are no data particularly pertinent to the economic activity of the estuary itself except, perhaps, the manufacture of transportation equipment.

Tables are given by subregion for:

1. Cumulative population growth
2. Per capita income
3. Export and residentiary employment

covering the year 1960 with 10-year projections from 1970 to 1990.

*REGIONAL ANALYSIS, *WATERSHEDS (BASINS), *ECONOMIC PREDICTION, employment, Maryland, Virginia, District of Columbia, river basins, industries, community development, data collections, occupations, Atlantic coastal plain, forecasting, regions, analysis, Appalachian Mountain region, coastal plains, geographical regions, northeast U. S., southeast U. S., cities, statistics.

410. A SUPPLEMENTARY REPORT ON THE COASTAL WETLANDS INVENTORY OF LONG ISLAND, NEW YORK, Fish and Wildlife Service, Division of River Basin Studies, June, 1965.

Aerial photographs and ground observations were used to determine the physical loss of wetlands since the initial survey in 1954; 13 percent were lost in 1954-59, 18 percent were lost in 1959-64. Thirty-four percent of the destruction was due to housing development, 17 percent to recreational development, 13 percent to industry, six percent to marinas and channels, four percent to airports, three percent to roads, and one percent to waste disposal.

Approximately 88 percent of the wetlands were considered vulnerable.

*WETLANDS, *LAND RECLAMATION, *SURVEYS, recreation, industries, marinas, recreation facilities, waste disposal, landfills, forecasting

411. 1965 SURVEY ON DISPOSAL OF SEWAGE AND INDUSTRIAL WASTES BY FEDERAL INSTALLATIONS, Thirty-First Report by the Committee on Government Operations, U. S. House of Representatives, 89th Congress, Second Session, House Report No. 1644, June 22, 1966.

The findings of this survey are reported by agency and individual facility. Estimates are presented for the daily volume of sewage discharge and the percentage treated. In addition, estimated daily discharges of cooling water are reported in connection with industrial discharges. Scheduled completion dates, by facility, for feasibility studies, engineering and design studies, and construction of facilities are listed.

*FEDERAL GOVERNMENT, *WATER POLLUTION CONTROL, *COOLING WATER, *INDUSTRIAL WASTES, *SEWAGE DISPOSAL, *DISCHARGE MEASUREMENT, sewage, sewage treatment, wastes, waste treatment, control, water types, governments, measurement

412. Sykes, J. E., MULTIPLE UTILIZATION OF GULF COAST ESTUARIES, 17th Annual Conference, Southeastern Association of Game and Fish Commissioners, 1963, pp. 323-326.

It is estimated that some 7500 square miles or 4,800,000 acres of estuarine area exists on the periphery of the Gulf of Mexico. Gulf commercial catches of fish and shellfish in 1960 consisted of over one billion pounds of estuarine dependent species. The contribution of Gulf estuaries toward these catches amounted to approximately 230 pounds per acre. The evaluation of estuaries is discussed in terms of total production including other forms of organic matter. Beneficial and detrimental uses of shallow-water coastal areas are cited.

*ESTUARINE FISHERIES, *PRODUCTIVITY, *GULF OF MEXICO, commercial fishing, commercial shellfish, multiple purpose, fisheries, animals, aquatic animals, aquatic life, invertebrates, shellfish, fishing, industries, bodies of water, gulfs, surface waters, coasts, beneficial use.

413. Sykes, James E., THE ROLE OF RESEARCH IN THE PRESERVATION OF ESTUARIES, 32nd North American Wildlife and Natural Resources Conference, San Francisco, California, Transactions, March 13-15, 1967, pp. 150-160.

The author cites landfill as a serious problem in many estuaries. Until the early nineteen sixties, little attention was paid to the ecological imbalances resulting from dredging and filling. One dredge-fill case is cited which set a precedent, inasmuch as it considered the data and evidence presented by marine biologists concerning the value of commercial and sport fishing of the area.

The author identifies other problems for estuarine research:

1. Altered circulation can cause erosion;
2. Dwellings built on new land masses are frequently exposed to hurricanes and sea storms;
3. Water quality, a factor related to biological production, recreation, and public health, is being neglected.

*LAND MANAGEMENT, *LANDFILLS, *ENVIRONMENTAL EFFECTS, *RESEARCH AND DEVELOPMENT, dredging, legal aspects, land forming, ecology, management, impaired water quality, water quality, erosion, conservation, fishing

414. TECHNOLOGY ADDING BILLIONS TO RESERVES, The Oil and Gas Journal, Vol. 66, No. 3, January 15, 1968, pp. 51-53.

The author discusses the gain in technology which save consumers billions of dollars and will add billions of barrels to oil reserves through the 1970's.

What technology has achieved since World War II:

Drilling Cost	Pared $7/foot
Produced Crude Cost	Slashed $1/bbl.
Oil-Recovery Rate	Improved 13 percent
Oil-Transportation Cost	Reduced 50 percent
Refinery - Operating Cost	Lowered 12 percent.

*OIL INDUSTRY, *TECHNOLOGY, *COST ANALYSIS, oil reservoirs, industries, drilling, transportation, analysis, mathematical studies

415. A TEN-YEAR PROGRAM OF FEDERAL WATER RESOURCES RESEARCH, Federal Council for Science and Technology, Committee on Water Resources Research, Office of Science and Technology, Executive Office of the President, February, 1966.

Recommendations for a ten-year program of Federal water resources research are given. One of the recommendations is that Federal research expenditures for research on estuarine problems be increased from an actual level of about $0.5 million annually in 1965 to an annual level of about $1.0 million by 1970.

*FUTURE PLANNING (PROJECTED), *WATER RESOURCES DEVELOPMENT, *FEDERAL BUDGETS, planning, resource development

416. Thayer, Richard P., and Richard G. Krutchoff, STOCHASTIC MODEL FOR POLLUTION AND DISSOLVED OXYGEN IN STREAMS, Water Resources Research Center, Virginia Polytechnical Institute, Blacksburg, Virginia, August, 1966.

The report deals with the problem of pollution and dissolved oxygen in rivers. The model provides a joint density function for both pollution and dissolved oxygen when initial conditions are assumed. Computer program has been developed which would predict the condition of the river for a given pollution loading condition.

*STATISTICAL MODELS, *DISSOLVED OXYGEN, *STOCHASTIC PROGRESS, biochemical oxygen demand, mathematical models, mathematical studies, model studies, oxygen demand, probability

417. Theriault, E. J., THE OXYGEN DEMAND OF POLLUTED WATER, Public Health Service, Department of Health, Education and Welfare, Bulletin No. 173, July, 1927.

Part I of the report contains data pertaining to the significance, validity, or fundamental theory of oxygen-demand tests and mathematical expressions defining time and temperature relationships. A critical review of Phelp's relative stability concept and other expressions defining the rate of deoxygenation are also presented.

Part II deals mainly with the experimental procedures, base data, the general course of the deoxygenation curve, the validity of deoxygenation formulae, and the applicability of the formulae to stream pollution and sewage treatment problems. The derivation of constants from observational equations of the unimolecular type is discussed to some extent.

*DISSOLVED OXYGEN, *SEWAGE TREATMENT, *STABILITY, *OXYGEN DEMAND, *MATHEMATICAL STUDIES, reaeration, water pollution, waste treatment

418. THERMAL POLLUTION OF WATER, Sport Fishing Institute Bulletin, No. 191, January 2, 1968.

This publication discusses the problem of thermal pollution and makes specific references to estuarine situations.

The article states that "the greatest source of thermal pollution is the steam-electric-station (S.E.S.) industry". It is predicted that thermal electric production in the United States will amount to 2,000 billion kw per hour by 1980. Such production will require 200 billion gallons of water per day, of which 94 percent would be used for cooling.

"It should also be noted that power plants are invading the estuaries at an accelerated rate. This is evidenced by the fact that 22 percent were located there in 1950, whereas some 32 percent are anticipated to be adjacent to estuaries by 1980."

The article also discusses the potential effects of thermal pollution on aquatic organisms, lists thermal criteria proposed by the National Technical Advisory Committee on Aquatic Life, discusses cooling tower alternatives for alleviating thermal pollution, and presents some data on sport fishing benefits in Biscayne Bay, Florida.

*THERMAL POLLUTION, *THERMAL POWERPLANTS, *STEAM TURBINES, *COOLING, nuclear powerplants, cooling towers, water sports, sport fishing, fishing, recreation, economic impact, water pollution, electric powerplants, engineering structures, industrial plants, powerplants, structures, equipment, turbines, aquatic life

419. Thomann, R. V., MATHEMATICAL MODEL FOR DISSOLVED OXYGEN, Journal of the Sanitary Engineering Division, Vol. 89, No. SA5, October, 1963, pp. 1-30.

A mathematical model for describing the time variation of dissolved oxygen in a finite number of sections in a body of water is presented. Systems analysis techniques are used, and the dissolved oxygen response equations resulting from the imposition of general input forcing functions are derived. Although the model as presented in its general form embodies all types of inputs and is capable of assessing the effects of any one time varying input in one section of the water body on the dissolved oxygen in any other section, the analytical model is presented for the case of DO variations in an estuary.

*DISSOLVED OXYGEN, *MATHEMATICAL MODELS, *WATER QUALITY, sewage effluents, mathematical studies, model studies, effluents

420. Thomann, R. V., RECENT RESULTS FROM A MATHEMATICAL MODEL OF WATER POLLUTION CONTROL IN THE DELAWARE ESTUARY, Water Resources Research, Vol. 1, No. 3, 1965, pp. 349-359.

The basic concepts of systems analysis and optimum (Least-cost) water pollution control are presented. The equations utilized to describe the time and space variability of dissolved oxygen are presented in a systems analysis context, and their usefulness in this form is discussed. The application of the mathematical model to the control of dissolved oxygen in the Delaware Estuary is given. Recent computer solutions are illustrated, and the sensitivity of the least-cost dissolved-oxygen improvement solutions to the rate of atmosphere reaeration is presented.

*MATHEMATICAL MODELS, *WATER POLLUTION CONTROL, *SYSTEMS ANALYSIS, *DELAWARE, *DISSOLVED OXYGEN, mathematical studies, model studies, reaeration, computers, costs, control, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions

421. Thomann, Robert V., "USE OF SYSTEMS ANALYSIS IN ESTUARINE WATER POLLUTION CONTROL", in NEW HORIZONS FOR RESOURCES RESEARCH, 1964, pp. 47-59. University of Colorado Press, Boulder, Colorado.

The author points to the need for "a useful causal description of the environment and the optimum design of the system in the light of this causal description". The criterion used in the article to determine the optimum design was one of least cost of implementation. In approaching the problem two basic techniques were used: (1) "a mathematical model of the environment using systems analysis or dyanmic control systems theory and (2) the use of linear programming formulation to achieve water quality goals at least cost using the mathematical description". The Delaware Estuary was used as one example, and suggestions were made on possible pollution control programs.

*SYSTEMS ANALYSIS, *WATER QUALITY, *WATER POLLUTION CONTROL, optimization, linear programming, mathematical studies, control, water quality control, quality control, cost analysis, analysis, Delaware River, bodies of water, interstate rivers, rivers, running waters, streams, surface waters, model studies

422. Thomann, Robert V., and Matthew J. Sobel, ESTUARINE WATER QUALITY MANAGEMENT AND FORECASTING, Journal of the Sanitary Engineering Division, Vol. 90, No. SA5, October, 1964, pp. 9-36.

The basic techniques of systems analysis are applied to describing time and space variations of dissolved oxygen in an estuary. The results of the analysis are applied to the annual variation of dissolved oxygen in the Delaware estuary. The analysis is further extended to include the formulation for optimum (least cost) solutions when specific dissolved oxygen goals are given. This latter approach uses linear programming techniques.

*SYSTEMS ANALYSIS, *FORECASTING, *WATER QUALITY CONTROL, *WATER POLLUTION, optimization, linear programming, water quality, mathematical studies, control, quality control, dissolved oxygen, Delaware River, bodies of water, interstate rivers, rivers, running waters, streams, surface waters, water pollution control, costs

423. Thompson, Seton H., WHAT IS HAPPENING TO OUR ESTUARIES, Twenty-Sixth North American Wildlife and Natural Resources Conference, Transactions, March, 1961, pp. 318-322.

This paper contains a short general discussion of the effects of land reclamation on estuarine fisheries. The author estimates that the estuarine zone of the Gulf and South Atlantic Coasts yields annually about 1.25 billion pounds of fish and shellfish, worth "upwards of $100 million".

The author suggests the states concerned with the effects of land reclamation in estuaries "could take three important steps in this direction:

1. Declare a moratorium on the sale of submerged lands. Our troubles begin when these lands fall into private hands.

2. Take inventory to ascertain ownership of all the submerged coastal areas.

3. Establish a Board, similar to a city's zoning commission, to determine the best uses to be made of our coastal waters.

The function of this proposed Board would be to develop an overall plan for each segment of our coast and avoid the piece-by-piece type of development we have been experiencing."

*LAND RECLAMATION, *ESTUARINE FISHERIES, *ECONOMIC IMPACT, *FISH HARVEST, commercial fishing, market value, employment, fishing, industries, fisheries, value, beds, ownership of beds, coasts, state jurisdiction, jurisdiction, federal jurisdiction

424. Throne, R. F., HOW TO PREDICT LAKE COOLING ACTION, Power, Vol. 95, September, 1951, p. 86.

The paper presents a mathematical approach to predict lake cooling action. The heat balance of the industrialized lake is superimposed on the heat balance of the natural lake. Various generalized equations and curves have been prepared to superimpose the effects of wind velocity, radiation, inflow rate, conduction, and evaporation. The results have applied to lakes in Oklahoma and Texas. For Colorado Lakes the predicted monthly temperatures of lakes were within ± 5 F of the actual temperatures.

*THERMAL POLLUTION, *HEAT BALANCE, *FORECASTING, *LAKES, *COOLING, water pollution, mathematical models, evaporation, conduction, radiation, bodies of water, regions, geographical regions, central U. S., inflow, standing waters, surface waters, mathematical studies, model studies, wind velocity, rates, velocity

425. Tobias, Leo, "PROTECTION AND RESTORATION OF BEACHES DURING AND AFTER OIL SPILLS", in MARINE, ESTUARIAN, AND RIPARIAN POLLUTION DISASTERS AND THEIR CONSEQUENCES, Ocean Resources Subcommittee Meeting, December 12, 1967. National Security Industrial Association, Washington, D. C.

Defensive measures taken to combat the "Torrey Canyon" oil spill were experimental in nature, since knowledge of effective techniques to combat oil spills is lacking.

The primary objective of oil spill defensive measures is to contain the oil at sea and prevent, as much as possible, the deposition of oil on the beaches.

Four methods are proposed in preventing the spread of oil on beaches: (1) use of a floating boom, (2) underwater bubble system, (3) covering beaches with polyethylene sheets, and (4) construction of a barrier dike.

If the beaches should become covered with oil, two restorative techniques are proposed: (1) the chemical method, using detergents to cleanse the oil, and (2) the mechanical method, involving removal of the oil-soaked layer of sand.

Although the chemical method is easier, it has been criticized for its harmful effect on the marine life of the area.

*OILY WATER, *BEACHES, *DISASTERS, shore protection, chemcontrol, environmental effects, mechanical control, water pollution control, water pollution treatment, control, physical control

426. Tollefson, Roger, BASIC BIOLOGICAL PRODUCTIVITY IN A MARINE INDUSTRIAL AREA, Water Pollution Control Federation, Journal, Vol. 35, No. 8, August, 1963, pp. 989-1005.

This paper calls attention to the magnitude of differences that may be encountered in any specific study as a result of variations of natural hydrographic conditions. This study was conducted in Bellingham Bay in the northern portion of Puget Sound in the State of Washington. It demonstrates that natural hydrographic variations were responsible for 85 percent of the standard deviations of the marine populations, and that the locations of the effluent discharge of an adjacent pulp and paper mill and the controlling natural fresh-water inflow to Bellingham Bay might easily have led to a conclusion of a biological depression resulting from "pollution". However, analyzing the data in relation to these natural hydrographic responses led to the clear, statistically confirmed conclusion that the mill effluents involved in this situation do not have any adverse effect upon the biological life of the receiving waters. Temperature was found to be nearly four times as important as salinity upon diatom population.

*SALINITY, *AQUATIC LIFE, *HYDROGRAPHY, *WATER TEMPERATURE, *WASHINGTON, water pollution effects, temperature, hydrologic aspects, chemical properties, water properties, regions, Pacific coast region, geographical regions, industrial wastes, wastes, effluents, population, aquatic population, discharge (water), Pacific northwest U. S.

427. Torpey, Wilbur N., RESPONSE TO POLLUTION OF NEW YORK HARBOR AND THAMES ESTUARY, Water Pollution Control Federation, Journal, Vol. 39, No. 11, November, 1967, pp. 1797-1809.

The author presents an historical analysis of the relationship between BOD loading and dissolved oxygen content of the waters in New York Harbor and the Thames Estuary in England.

The findings appear to have important implications for estuarine management. The principal conclusion was that, for both of these estuaries, "...the curve defining the relationship of organic loading rate to dissolved oxygen is considerably distorted. It does not follow the smooth path of the oxygen-sag formulations."

An unexpected finding leading to the general conclusion was that for New York Harbor "...between 1916 and 1937 the rate of application of organic load to the harbor waters more than doubled, yet the DO concentration remained substantially unchanged. After 1937, the load on the harbor was relieved greatly by the successive installation of facilities providing secondary treatment for the wastes of about four million people, yet an improvement of only five percent in the oxygen saturation was realized. Apparently, a plateau approximating 43 percent oxygen saturation exists when the organic load applied to New York Harbor water lies in the range of 3,500,000-8,000,000 people. The loading increase by 4,500,000 people and subsequent decrease by 3,000,000 was not reflected in the DO content of the waters. This behavior was, to say the least, unexpected."

The author summarizes his findings as follows:

"Under light pollutional loading the ecology is composed of higher forms of biological life such as crustacea, mollusks, and fish. When the loading increases to a rate requiring about 20 lb. oxygen/day/acre (22 kg/day/ha) instability develops, the oxygen level drops sharply, and the fish migrate. When the waters receive loading rates that require 20-132 lb/day/acre (22-148 kg/day/ha) the DO remains substantially constant for the subject 30-ft-(9-m-) deep estuaries, at between 25 and 50 percent of saturation. This zone of the DO plateau is homeostatic in nature because the symbiotic activities of algae and bacteria are able, with an assist from the atmosphere, to supply enough oxygen to accommodate load variations. However, when the loading rate exceeds an upper threshold, wherein more than about 132 lb oxygen/day/acre (148 kg/day/ha) was required, the oxygen was exhausted and anaerobic conditions ensued."

*DISSOLVED OXYGEN, *BIOCHEMICAL OXYGEN DEMAND, *SEWAGE, *WATER POLLUTION, *HARBORS, *NEW YORK, *FOREIGN COUNTRIES, ecology, oxygen demand, wastes, organic matter, Appalachian Mountain region, geographical regions, Great Lakes region, northeast U. S., regions, water quality, waste treatment

428. TOURISM AND RECREATION, Arthur D. Little, Inc., Cambridge, Massachusetts, Project No. C-68388, October 10, 1966.

This report appears to be based on a literature search on recreation and tourism. It encompasses leisure time activities in the United States, as a whole.

Chapters on boating, hunting, and sport fishing in the United States are included.

The report contains a large bibliography.

*RECREATION, *TOURISM, *BIBLIOGRAPHIES, water sports, fishing, boating, sport fishing, hunting

429. Train, Russell E., A CALL FOR ACTION, Conservation Foundation Letter, April 22, 1968, p. 12.

A program for estuarine preservation is proposed:

1. Every coastal state should declare a moratorium on tampering with major estuaries and at the same time create conservation and development commissions to study each estuary, prepare a plan for the estuary, and present the alternatives to the people and governments involved.

2. Conservation and environmental values in general should be included in determining if permits shall be issued for dredging and filling.

3. A national inventory of estuaries should be included in a system of protected estuaries.

4. Customary techniques of computing cost-benefit ratios should be reassessed. We do not yet know how to determine and assign values to the intangibles of a quality environment. We remain at the mercy of development accounting, which measures costs against benefits without including the cost of degrading the environment alone. Such a reassessment would be a logical assignment for a Presidential Council of Environmental Advisors; but, lacking such a council, the assignment might well be given to a special Presidential task force.

*LEGISLATION, *COST-BENEFIT RATIO, *PLANNING, *ENVIRONMENTAL EFFECTS, *ESTUARINE ENVIRONMENT, conservation, aquatic environment, governments, federal government

430. Turner, C. H., E. E. Ebert, and R. G. Given, THE MARINE ENVIRONMENT IN THE VICINITY OF THE ORANGE COUNTY SANITATION DISTRICTS OCEAN OUTFALL, California Fish and Game, Vol. 52, No. 1, 1966, pp. 28-48.

The authors report that a biological survey in the area of a sewer outfall showed that there was generally a typical faunistic assemblage for the depths and substrates examined. Two exceptions were (1) a reduced number of species encrusting the last 100 feet of the outfall pipe as compared to the central portion and (2) considerably fewer kinds and numbers of organisms on an artificial reef in the area as compared to other artificial reefs exposed for the same time at the same depths.

*ECOLOGY, *MARINE ANIMALS, *SEWAGE EFFLUENTS, *WATER POLLUTION EFFECTS, *CALIFORNIA, water pollution sources, effluents, animals, aquatic animals, aquatic life, geographical regions, Pacific coast region, regions, southwest U. S., outlets

431. Underhill, A. H., MAINTAINING AND ENHANCING THE ESTUARINE ENVIRONMENT, A Symposium on Estuarine Fisheries, American Fisheries Society, Special Publication No. 3, 1966, pp. 127-129.

This paper presents a brief general discussion of different means of accomplishing preservation of valuable estuarine areas by a representative of the U. S. Bureau of Outdoor Recreation. The means which the author suggests as having merit are "(1) public ownership, (2) zoning, (3) comprehensive planning by interagency groups, and (4) legislation, at all levels of government, to support zoning, comprehensive planning, and other necessary actions".

*LAND RECLAMATION, *ZONING, *LEGISLATION, *ESTUARINE ENVIRONMENT, management, planning, regulation, governments

432. A USER-RESOURCE RECREATION PLANNING METHOD, National Advisory Council on Regional Recreation Planning, Hidden Valley, Loomis, California, 1959.

This study analyzes the user-resource relationship in recreation. Guides for recreation planning are set down, and recreation values are defined:

1. Those values that are derived from "the basic resource", the land itself;

2. The direct and indirect benefits to individuals and society.

Recreation potential of varying land types for different activities is discussed. Cost/benefit data for providing recreation areas to user groups is given.

*RECREATION DEMAND, *LAND MANAGEMENT, *PROJECT PLANNING, *COST-BENEFIT ANALYSIS, natural resources, planning, management, resources

433. "UTILIZATION OF THE ESTUARINE ZONE IN GEORGIA--A STATEMENT BY BIOLOGISTS FROM THE DIVISION OF BIOLOGICAL SCIENCES OF THE UNIVERSITY OF GEORGIA", in CLEAN WATER FOR THE NATION'S ESTUARIES, Proceedings of the Georgia Public Meeting, Jekyll Island, Georgia, February 29, 1968, pp. 1-15. Federal Water Pollution Control Administration, Department of the Interior, S. E. Region, Atlanta, Georgia.

The statement discusses effects which various uses will have on the estuarine region. Six aspects are covered in the report:

1. Description of physical and biological aspects of estuaries.
2. Emphasis on unique features of the estuarine complex in Georgia.
3. Historical background of estuarine degradation along the east coast of the United States (New Jersey and Florida).
4. Description of uses and value of salt marsh-estuarine complex in its present form and kinds of uses to which it may be put.
5. Effects of various pollutants on estuaries.
6. Recommendation of plans for zoning of the estuarine region of Georgia to separate incompatible uses as well as pollutants.

Waste disposal is the biggest industrial use of Georgia's estuarine zones; sport fishing is the next important use, amounting to $51,000,000 in revenues in 1963; and commercial fishing follows with a value placed at $10,000,000 in 1965. Many of Georgia's estuaries still approximate their natural condition, which is important to research.

*GEORGIA, *WATER POLLUTION EFFECTS, *WATER UTILIZATION, *VALUE, planning, water quality control, control, quality control, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, regions, southeast U. S., history, efficiencies

434. THE VALUE OF A TON OF CARGO TO THE AREA'S ECONOMY--PHILADELPHIA PORT AREA, Port Development Department, Delaware River Port Authority, Camden, New Jersey, September, 1953.

This is a survey of the direct dollar impact of the waterborne commerce of the Delaware River port. Seven selected commodities (general cargo, crude oil, tanker cargo other than crude oil, coal, grain, ore, and raw sugar) were used to estimate the direct dollar revenue produced in this area by the operations of the port.

*HARBORS, *DELAWARE RIVER, *INCOME, *ECONOMIC IMPACT, value, bodies of water, interstate rivers, rivers, running waters, streams, surface waters, monetary benefits, Delaware, Atlantic coastal plain, coastal plains, geographical regions, northeast U. S., regions, New Jersey, Pennsylvania, Appalachian Mountain region, Great Lakes region, benefits, investigations

435. THE VALUE OF A TON OF GENERAL CARGO TO THE AREA'S ECONOMY--DELAWARE RIVER PORT, Division of Port Development, Delaware River Port Authority, Camden, New Jersey, 1962.

This is a revision of the original study of the same title which was issued in 1953. The revision has been limited to updating the value of a ton of general cargo over the period between 1950 and 1962 from $11.33 to $16.22.

*HARBORS, *DELAWARE RIVER, *ECONOMIC IMPACT, *INFLATION (ECONOMIC), income, value, bodies of water, interstate rivers, rivers, running waters, streams, surface waters

436. OUR VANISHING SHORELINE, Department of the Interior, National Park Service.

The study findings indicate that almost all suitable seashore area on the Atlantic coast has been purchased and is under private ownership, unavailable for public use. Inaccessible beaches and a few off-shore islands are the last hope for public seashores, but they too are rapidly being bought for real estate development.

The National Park Service makes six recommendations:

1. Fifteen percent of the Atlantic and Gulf coast be acquired by public agencies for public recreation purposes.
2. This be done immediately before the situation deteriorates further.
3. Acquisition be related to population distribution, when possible.
4. Marsh and swamp lands be acquired and protected.
5. Plant-animal communities be acquired and protected.
6. Land use studies and zoning be considered.

*RECREATION FACILITIES, *SEASHORE, *CONSERVATION, beaches, recreation demand, parks, social aspects, government supports, shores, national parks

437. Van Veen, J., DREDGE DRAIN RECLAIM: THE ART OF A NATION, 1948. Trio Printers, The Hague, Netherlands.

A historical treatment of land reclamation and land reclamation methods in the Netherlands, from the beginning of recorded history. The historical development of the Amsterdam and Rottendam waterways, canals for inland shipping, and the reclamation of the Zuiderzee are discussed. It has been estimated that about 1,453,000 acres had been reclaimed since 1200 AD, and about 390,000 acres were in process of reclamation in 1948. Estimated total earth moved has been about 10 billion cubic yards. The old generation of Zuiderzee fishermen had sad forebodings when their sea became a lake, but more value of fish is caught now than when the Zuiderzee was still an open tidal bay.

*LAND RECLAMATION, *COMMERCIAL FISHING, *INLAND WATERWAYS, *DIKES, dredging, flood protection, channel improvement, shore protection, channels, fishing, industries, history, canal construction, construction, earthworks, embankments, engineering structures, hydraulic structures, structures, foreign countries, geographical regions, regions

438. Velz, C. J., and J. J. Gannon, FORECASTING HEAT LOSS IN PONDS AND STREAMS, Water Pollution Control Federation, Journal, Vol. 32, No. 4, April, 1960, p. 392.

The authors present a rational method for forecasting expected water temperature conditions in streams and ponds based on probability of occurrence of the controlling meteorologic and hydrologic variables. It is possible to evaluate temperature effects before constructing industries and steam power plants. Basic equations involve effect of evaporation, convection, radiation, atmospheric vapor pressure, wind velocity, and air temperature.

*FORECASTING, *HEAT BALANCE, *THERMAL POLLUTION, *WATER TEMPERATURE, thermal properties, pressure, physical properties, vapor pressure, radiation, wind pressure, heated water, cooling, water types, streams, bodies of water, water pollution, circulation, convection, evaporation, industries, water properties, running waters, ponds, lakes, standing waters, hydrologic data, meteorological data, temperature.

439. Verross, William J., "STATEMENT", in CLEAN WATERS FOR THE NATION'S ESTUARIES, Proceedings of the Georgia Public Meeting, Jekyll Island, Georgia, February 29, 1968, pp. 46-52. Federal Water Pollution Control Administration, Department of the Interior, S. E. Region, Atlanta, Georgia.

The Georgia Pulp and Paper Association submits the following points for consideration:

1. Georgia's existing law, rules, and standards involving water quality are more than adequate to protect the state's estuaries and coastal waters.

2. There is need for a great deal more research on the ecology of estuaries before additional regulation or legislation is imposed over coastal waters.

3. The Georgia Pulp and Paper Association feels that concurrent multiple use of estuaries is possible, desirable, and practical.

*WATER QUALITY, *LEGISLATION, *WATER UTILIZATION, *GEORGIA, *PULP AND PAPER INDUSTRY, water pollution control, water pollution, water pollution sources, ecology, industries, efficiencies, Appalachian Mountain region, Atlantic coastal plain, coastal plains, geographical regions, regions, southeast U. S.

440. Walford, Lionel, PROBLEMS OF CONSERVATION IN THE ATLANTIC ESTUARINE ZONE, 32nd North American Wildlife and Natural Resources Conference, Transactions, March 13-15, 1967, pp. 161-164.

The author says that the "resort industry" of the Atlantic coastal lowlands has had a tendency towards self-destruction in its failure to recognize and nurture the resource base on which it rests. The vast population which inhabits the Atlantic estuarine zone tends to associate itself with metropolitan rather than regional needs; therefore the responsibility of estuarine conservation rest on fragmented agencies within state and local government. If it is desired to conserve the quality of the environment in the Atlantic estuarine zone, the principal question is not how can states rights be preserved, but how can states work together in designing the uses of the zone so as to protect their common resources.

*WATER RESOURCES DEVELOPMENT, *GOVERNMENTS, *ATLANTIC COASTAL PLAIN, *RECREATION FACILITIES, social aspects, conservation, resource development, legislation, recreation, water sports, outdoor recreation, social impact, local governments, state governments, coastal plains, geographical regions, regions, sport fishing, fishing, wildlife conservation.

441. Walford, Lionel, STATEMENT ON LIVING MARINE RESOURCES OF WETLANDS AND ESTUARIES, Estuarine Hearings, Subcommittee on Fisheries and Wildlife Conservation of the Committee on Merchant Marine and Fisheries, House of Representatives, 90th Congress, Serial No. 90-3, March 1967.

Most of the world's population is concentrated on the seacoasts. At the same time more than 90 percent of food fish live in coastal waters.

The Atlantic estuary is exceptionally productive. Five cases are cited where the fishery resources have been damaged.

*DAMAGES, *WETLANDS, *ESTUARINE FISHERIES, *COMMERCIAL FISHING, *ESTUARINE ENVIRONMENT, *ATLANTIC OCEAN, value of estuary, fisheries, aquatic environment, fishing, fish, industries, commercial shellfish, wildlife conservation, coasts, bodies of water, oceans, surface waters, animals, aquatic animals, aquatic life, invertebrates, shellfish, natural resources, resources, marine fish, saline water fish, wildlife, conservation

442. WASTE FROM WATERCRAFT, Federal Water Pollution Control Administration, Department of the Interior, Washington, D. C., 90th Congress, First Session, Senate Document No. 48, August, 1967.

This document, a report on vessel pollution in the navigable waters of the U. S., was submitted by the Secretary of the Interior to the 90th Congress, in compliance with the Clean Water Restoration Act of 1966. The report contains basic data and information on the following:

1. Dimensions, sources, and effects of the watercraft pollution problem.
2. Pollution control mechanisms.
3. Summary of existing laws and regulations (both federal and state) regarding watercraft pollution problem.
4. Ongoing activities on controlling watercraft pollution.

Also, a proposed program for the control of pollution from vessels is outlined.

*WATER POLLUTION, *SHIPS, *FEDERAL GOVERNMENT, *LEGISLATION, *NAVIGABLE WATERS, *WASTES, governments, bodies of water, water pollution control, control, water pollution effects, data collections

443. Wastler, T. A., and L. C. deGuerrero, NATIONAL ESTUARINE INVENTORY: HANDBOOK OF DESCRIPTIONS, June, 1968. Department of the Interior, Federal Water Pollution Control Administration, Division of Technical Services, Office of Estuarine Studies, Washington, D. C.

The handbook is a skeleton for the recording of information. It consists of a set of tables for the organization of information and data. It is designed for the National Estuarine Pollution Study. The appendix contains a list of all estuaries in United States boundaries.

*DOCUMENTATION, *INFORMATION RETRIEVAL, *UNITED STATES, *ESTUARINE ENVIRONMENT, *WATER POLLUTION, geographical regions, regions, aquatic environment, environment

444. WATER DESALINATION: PROPOSALS FOR A COSTING PROCEDURE AND RELATED TECHNICAL AND ECONOMIC CONSIDERATIONS, United Nations, New York, 1965.

Part I of this report gives a breakdown of the principal cost items to be included under investment for desalination and proposes a procedure to obtain an approximate cost for product water. Part II reviews the technical and economic considerations encountered in the selection, construction, and operation of desalination plants.

*DESALINATION, *INVESTMENT, *COSTS, saline water, demineralization, separation techniques, water purification, water treatment, water types, capital costs, operating costs, construction costs

445. WATER IN INDUSTRY: A SURVEY OF WATER USE IN INDUSTRY, National Association of Manufacturers, New York, and Chamber of Commerce of the United States, Washington, D. C., January, 1965.

The findings of a survey of industrial water use and waste treatment are reported. Intake water volume and process water treatment costs are estimated for various industries. Operating and capital replacement costs are also estimated for effluent treatment facilities. Sundry other quantitative estimates relating to industrial water use, including salt or brackish water intake for several industries, are given. Separate sections are included for the following industries: automobile industry, sugar beet industry, bituminous coal industry, cane sugar industry, chemical manufacturing, grain beverage distilling industry, investor-owned electric utility industry, industrial laundering, meat industry, petroleum refineries, pulp and paper industry, soap and detergent industry, steel industry, and tanning-leather industry.

*WATER UTILIZATION, *INDUSTRIAL WATER, *WASTE WATER TREATMENT, *OPERATING COSTS, *SURVEYS, industrial wastes, water pollution, pollution abatement, capital costs, efficiencies, water types, wastes, waste treatment, water treatment, abatement, costs

446. WATER POLLUTION CONTROL FACTS, Water Pollution Control Federation, Washington, D. C., 1965.

This report discusses various pertinent statistical data regarding pollution control requirements and costs, drawn from various publicly available publications. The content is indicated by the following table headings:

New Sewer and Water Construction Put in Place in the United States, 1963, 1964, and Outlook for 1965;

Construction Needs for Sewerage Utilities, Public and Private, 1962-70;

Estimated Costs for Complete Separation of Stormwater and Sanitary Sewers;

Estimated Costs for Partial Separation of Stormwater and Sanitary Sewers;

Summary of the Backlog of Municipal Wastewater Treatment Needs, 1964;
Present Municipal Wastewater Treatment Needs;
Required Annual Construction Rates, Municipal Wastewater Treatment Works;
Increase in Organic Industrial Wastes (Industrial);
1959 Operating and Replacement Costs for Industry Wastewater Treatment Facilities;
Industrial Plants Providing No Treatment in 1959;
Treatment Processes Most Frequently Mentioned by 2,162 Respondents;
Water Plans; and
1959 Capital Expenditures for Construction of Wastewater Collection and Treatment Systems by Percent and Dollar Distribution.

*WATER POLLUTION CONTROL, *STATISTICS, *MUNICIPAL WASTES, *SEWERS, *ESTIMATED COSTS, Waste water treatment, sewage treatment, industrial wastes, data collections, wastes, conduits, conveyance structures, engineering structures, hydraulic structures, control, waste treatment, planning, costs, construction

447. WATER QUALITY AND POLLUTION CONTROL STUDY - JAMES RIVER BASIN, Federal Water Pollution Control Administration, Middle Atlantic Region, CB-SRBP Working Document No. 14, June, 1967.

This report covers immediate pollution control needs and estimated costs for providing these needs. The present water-quality conditions and biological study of the upper reaches of the James River and tributaries are summarized. The following basic criteria were used in achieving cost estimates for new facilities:

1. Dissolved oxygen not lower than 4 mg/1 in the stream,
2. No appreciable settleable or floating solids,
3. No noticeable coloration or discoloration of receiving streams,
4. Toxic substances to be reduced below the toxicity of streams,
5. No appreciable change in pH of the receiving streams, and
6. Stream flow for design of sewage treatment facilities equal to minimum average seven-day low flow occurring on 10-year frequency.

*WATER QUALITY, *WATER POLLUTION CONTROL, *RIVER BASINS, *ESTIMATED COSTS, chemical properties, dissolved oxygen, hydrogen ion concentration, regions, costs, solid wastes, wastes, toxicity, sewage treatment, waste treatment, control

448. WATER QUALITY CRITERIA--STREAM VERSUS EFFLUENT STANDARDS, Water Pollution Control Federation, Journal, Vol. 37, No. 3, March 1965, pp. 292-315.

A series of papers giving their authors' views relating to the subject. The papers and authors are as follows: "Industry Views", by Harold L. Jacobs; "Conservation View", by Ira N. Gabrielson; "An Index-Number System for Rating Water Quality", by Robert K. Horton; "Some Thoughts About Effluent Standards", by Walter A. Lyon; "Stream Standards", by Earle C. Hubbard; and "Water Quality Criteria Development", by Gordon E. McCallum.

*WATER QUALITY, *STANDARDS, *QUALITY CONTROL, *STREAMS, effluents, control, bodies of water, running waters

449. WATER REQUIREMENTS OF ELECTRIC UTILITY STEAM-ELECTRIC-GENERATING PLANTS IN 1959, Federal Power Commission, Bureau of Power, Washington, D. C., May, 1961.

This report summarizes water use by steam-electric generating plants in the United States (excluding Alaska and Hawaii) for the year 1959. The data are summarized by geographic area, fresh or brackish supply, recirculation, losses, and amount discharged.

*ELECTRIC POWER INDUSTRY, *ELECTRIC POWERPLANTS, *WATER REQUIREMENTS, cooling water, water utilization, water supply, industries, engineering structures, industrial plants, powerplants, structures, water types, efficiencies, supply, recirculated water, steam

450. WATER RESOURCES ACTIVITIES IN THE UNITED STATES: ELECTRIC POWER IN RELATION TO THE NATION'S WATER RESOURCES, Senate Select Committee on Water Resources, United States Senate, Washington, D. C., Committee Print No. 10, 1960.

An analysis is made of the determinants of electric-power production, by basic energy source, in the United States. Electric-power production is projected through 1980 by energy source and regions. Cooling water requirements for electricity production are also projected.

*ELECTRIC POWER, *COOLING WATER, *FORECASTING, electricity, water types

451. WATER RESOURCES ACTIVITIES IN THE UNITED STATES: WATER SUPPLY AND DEMAND, Select Committee on National Water Resources, United States Senate, 86th Congress, Committee Print No. 32, August, 1960.

This is a report on the nation's prospective supply of and demand for water in 1980 and 2000. The overall results are summarized and tabulated for the entire country by water resources regions.

*WATER SUPPLY, *WATER DEMAND, *UNITED STATES, *REGIONAL ANALYSIS, *FORECASTING, water resources development, geographical regions, regions, demand, supply

452. WATER RESOURCES RESEARCH CATALOG, Office of Water Resources Research, Department of the Interior, Washington, D. C., Vol. 1, February, 1965.

This publication is an annotated compilation to all federally-supported water resources research in progress as of February, 1965.

*WATER RESOURCES DEVELOPMENT, *BIBLIOGRAPHIES, *RESEARCH AND DEVELOPMENT, *FEDERAL GOVERNMENT, governments

453. WATER USE IN MANUFACTURING, 1963 CENSUS OF MANUFACTURES, Bureau of the Census, Department of Commerce, 1963.

This is a report of the 1963 Census of Manufactures data. Water-use data are cited for 2-, 3-, and 4-digit SIC industries by geographical regions and by specific use category.

*WATER UTILIZATION, *GEOGRAPHICAL REGIONS, *INDUSTRIAL PLANTS, efficiencies, buildings, engineering structures, structures, regions, industrial water, water types

454. WATERBORNE COMMERCE OF THE UNITED STATES, Annual Publication. Department of the Army, Corps of Engineers, Washington, D. C.

These publications present data on the movements of commodities and vessels at the ports, harbors, waterways, and canals of the United States and the territories and possessions. Both the foreign and domestic commerce of the United States by water are included for the Atlantic coast, Gulf coast, Mississippi systems, Antilles, Great Lakes, Pacific coast, Alaska, and Hawaii. National summaries are also included.

*TRANSPORTATION, *SHIPS, *HARBORS, *DATA COLLECTIONS, transfer, channels, canals, conduits, conveyance structures, engineering structures, hydraulic structures, streams, Great Lakes, Pacific Ocean, standing waters, lakes, open channels, structures, coasts, Atlantic Ocean, bodies of water, oceans, surface waters, Gulf of Mexico, gulfs, Mississippi River, interstate rivers, rivers, running waters, Pacific northwest U. S., Alaska, geographical regions, Pacific coast region, regions, Hawaii, Pacific northwest U. S., Alaska, geographical regions, Pacific coast region, regions, Hawaii, islands, southeast U. S., northeast U. S.

455. WATERSIDE SITE PLANT LOCATIONS AND EXPANSIONS 1966, March, 1967. The American Waterways Operators, Inc., Washington, D. C.

The American Waterways Operators, Inc., has kept records on the growth of industrial waterside production facilities and water-borne commerce shipping facilities for the past 14 years (since 1953). This booklet, one of a continuing series which started in 1961, lists the individual facilities built, expanded, or planned for construction on waterfront sites in 1966, by individual rivers and bays.

*CONSTRUCTION, *SITES, *INDUSTRIAL PLANTS, *STATISTICS, rivers, bays, harbors, bodies of water, running waters, streams, surface waters, buildings, engineering structures, structures, data collections

456. Weber, Eugene W., RECREATION--A PURPOSE OF WATER RESOURCES DEVELOPMENT, Civil Engineering, Vol. 32, No. 9, September, 1962, pp. 57-59.

Federal reservoirs, which once were constructed for flood control, power development, and water supply, now include recreation as a prime purpose for construction. This was partly due to the demand for recreation at the Corps of Engineers reservoirs which has been increasing at a rate of about three times the annual rate of increase in the nation's GNP and about six times the rate of its population growth.

It is now incumbent on planners to insure that:

1. Projections of future needs include estimates of the probably demand for recreation,
2. Projects are designed to minimize loss of existing and inherent recreational values,
3. Projects are designed to permit realization of their recreational potential to the full extent justified by the prospective demand, and
4. Recreation is evaluated on a basis comparable to that used for other project purposes to insure that net benefits, tangible and intangible, for all purposes are maximized.

*RECREATION FACILITIES, *RECREATION DEMAND, *PLANNING, *RESERVOIRS, recreation, multiple-purpose reservoirs, demand, bodies of water, impoundments, lakes, standing waters, surface waters, efficiencies, water utilization, federal project policy

457. Weil, M. H., PAST, PRESENT AND FUTURE OF SPORT FISHING IN TEXAS WATERS, 11th International Game Fish Conference (1966), Proceedings, August, 1967, pp. 59-65.

The author states that sport fishing in Texas waters has improved and argues that it should continue to improve. The author feels that with more people fishing, plus changes in the ecology of the area such as the damming of rivers, soil conservation practices, channel dredging for industrial development, and increased boat traffic, fishing values are affected. He feels, however, that new habitat can be encouraged to replace the old areas which may become lost. Specific examples are cited.

*SPORT FISHING, *TEXAS, *HABITATS, *FORECASTING, channel improvement, dams, soil conservation, recreation, fishing, water sports, central U. S., coastal plains, geographical regions, Gulf coastal plain, regions, southwest U. S., history, environments, conservation, dredging

458. Weis, N. E., and S. W. McFarland, THE IMPACT OF THE PORT OF JACKSONVILLE ON THE ECONOMY OF THE COMMUNITY, Division of Business Administration, Jacksonville University, Jacksonville, Florida, 1965.

The volume of income resulting from and generated by the flow of goods imported and exported at the Jacksonville Talleyrand Docks and Terminal facilities during 1964 is analyzed. Principal attention is placed on an analysis of the factors and conditions which contributed to the flow of income both as a direct result of the activities of this port facility and as an indirect result of income flow from supporting services and industries. Community benefits in wages, taxes, and services are evaluated.

*HARBORS, *ECONOMIC IMPACT, *FLORIDA, income, employment, wages, Atlantic coastal plain, coastal plains, geographical regions, Gulf coastal plain, regions, southeast U. S., income analysis, analysis, mathematical studies, economic life, benefits

459. WEST COAST OIL FUTURE IS BRIGHT, Offshore, Vol. 27, No. 7, June 20, 1967, pp. 70-74.

The author discusses the future of West Coast oil fields. Also discussed are the future leasing potentials and bonuses.

*OIL INDUSTRY, *OIL FIELDS, *FUTURE PLANNING (PROJECTED), oil reservoirs, industries, planning forecasting, leases, Pacific coast region, geographical regions, regions

460. Wheeler, D. L., LAND RECLAMATION IN THE PO RIVER DELTA OF ITALY, Land Economics, Vol. 41, 1965, pp. 376-382.

Work was started in 1952 to drain the Valli Pega marshes on the Adriatic Sea south of the village of Comacchio. A dike was constructed, and the land was drained by 1954. By 1956 the first 900 acres was planted.

Today, 6,876 acres are planted to wheat, rape-seed, and lucerne, which are especially well adapted to reclaimed soils. The contraction of the soil as the moisture content is reduced will be the most difficult future problem requiring rebuilding of present structures.

Anticipated cost is $4 million; $2,300 per settler for the initial project. The long range plans are to drain 75,000 acres and resettle 7,500 people on the land. Many of these people are fishermen in the area who will be taught how to farm. The gradual development program is designed so as not to upset the economy by destroying the fishing resource before alternatives can be provided to the indigenous population. Reclamation of the entire Valli de Comacchio will cost $5.7 million.

*LAND RECLAMATION, *LAND DEVELOPMENT, *CULTIVATION, *DIKES, *FOREIGN COUNTRIES, marshes, wetlands, land management, soil management, management, earthworks, embankments, geographical regions, regions, engineering structures, hydraulic structures, structures, surface drainage, drainage

461. Whipple, William, Jr., ECONOMIC BASIS FOR EFFLUENT CHARGES AND SUBSIDIES, Water Resources Research, Vol. 2, No. 1, 1966

The author sets forth the microeconomic theoretical basis for examining the reasonableness of effluent charges and subsidies as a means of pollution control.

*ECONOMIC EFFICIENCY, *WATER POLLUTION CONTROL, *EFFLUENTS, *ASSESSMENTS, control

462. Wildavsky, Aaron, THE POLITICAL ECONOMY OF EFFICIENCY: COST-BENEFIT ANALYSIS, SYSTEMS ANALYSIS, AND PROGRAM BUDGETING, Public Administration Review, Vol. 26, No. 5, December, 1966, pp. 292-310.

Some of the useful features and shortcomings of cost-benefit analysis, systems analysis, and program budgeting techniques for achieving economic efficiency are pointed out. Also discussed are the political realities involved in the application of these techniques, as well as the interrelationship between programs for economic efficiency and the political process.

*COST-BENEFIT ANALYSIS, *SYSTEMS ANALYSIS, *FINANCIAL FEASIBILITY, *POLITICAL ASPECTS, programs, decision making, economic efficiency, budgeting, administration, financial analysis, cost comparisons, governments, local governments, political constraints, constraints

463. Woodburn, Kenneth D., A GUIDE TO THE CONSERVATION OF SHORELINES, SUBMERGED BOTTOMS AND SALTWATERS WITH SPECIAL REFERENCE TO BULKHEAD LINES, DREDGING AND FILLING, Marine Laboratory, Salt Water Fisheries Division, Florida Board of Conservation, St. Petersburg, Florida, Educational Bulletin No. 14, September, 1963.

A guide is presented for evaluating marine productivity and adopting standards for waterfront development. Some of the factors considered include: the use of field inspection, interviews and consultation, and publications and maps. Guidelines that were developed for Manatee County by the Florida Board of Conservation for establishment of bulkhead lines are listed. The approach suggested appears to be based primarily upon the making of qualitative judgments rather than evaluation of economic "trade-offs".

*CONSERVATION, *SHORES, *BEDS, *SALINE WATER, landfills, land development, dredging, bulkhead line, water types, standards, on-site investigations, maps, publications, Florida, Atlantic coastal plain, coastal plains, geographical regions, Gulf coast plain, regions, southeast U. S.

464. Woodward, George M., COMMERCIAL FISHERIES OF NORTH CAROLINA - AN ECONOMIC ANALYSIS, 1956. University of North Carolina, Chapel Hill, North Carolina.

The first part of this book describes the fishing industry in general in the U. S. and then deals specifically with the North Carolina fisheries. The industry is discussed in terms of its size, rate of growth, and its place in the economy of North Carolina and in the U. S. economy. The author also discusses future prospects of the industry. Graphs and tables are provided showing trends in values of fisheries' products and incomes from approximately 1930 through 1955.

Part two is devoted to an economic outlook for the finfisheries of North Carolina. Data are provided for a variety of commercial finfish.

Parts three and four are devoted to the oyster fishery and shrimp fishery respectively. The author considers these to be the most economically important shellfisheries in North Carolina. Trends in production and income from these fisheries are reported through 1955.

Part five is a discussion of the processing of fishery products.

*NORTH CAROLINA, *COMMERCIAL FISH, *ECONOMIC IMPACT, *COMMERCIAL SHELLFISH, water sports, recreation, Atlantic coastal plain, Appalachian Mountain region, marine fisheries, fisheries, competition, labor supply, cost analysis, shellfish, oysters, analysis, shrimps, marketing, sport fishing, animals, aquatic animals, southeast U. S., regions, geographical regions, coastal plains, aquatic life, fish, wildlife, benthic fauna, benthos, invertebrates, marine animals, mollusks, economic prediction, forecasting, value, market value, supply, mathematical studies

465. Wurtz, C. B., "COMMON MISUNDERSTANDINGS ABOUT HEATED DISCHARGES", in CLEAN WATER FOR THE NATION's ESTUARIES, Transcript of Public Meeting, Biloxi, Mississippi, January 17, 1968, p. 4. Federal Water Pollution Control Administration, Department of the Interior, S. E. Region, Atlanta, Georgia.

The author describes five common misunderstandings about the effects of heated discharges on aquatic life. These misunderstandings relate to the belief that an increase in water temperature will:

1. Cause a reduction in the capacity of the water to retain dissolved oxygen.
2. Cause a deterioration in the "quality" of the biological community, i.e., less desirable species of organisms will replace more desirable species. This is usually argued as an increase of only two or three degrees without any scale being mentioned.
3. Cause fish to spawn earlier, and a time when suitable food organisms for survival of the young stages will not be present.
4. Change metabolic rates to the extent that individual organisms will be living under conditions of physiological stress, and thus be vulnerable to adverse conditions they may have otherwise resisted.
5. Cause an increase in the numbers of predators, parasites, and/or pathogens, and thus cause significant deterioration of a fisheries resource or create a public health hazard.

*HYDROELECTRIC PLANTS, *HEATED WATER, *ECOLOGY, *AQUATIC ANIMALS, *THERMAL POLLUTION, predation, pathogenic bacteria, physiological ecology, animal metabolism, animal parasites, water quality, bacteria, electric powerplants, engineering structures, industrial plants, structures, powerplants, afterbays, spawning, wildlife, dissolved oxygen, fish, animals, aquatic life, food chains, water types, fisheries, public health, microorganisms, plants

466. Young, P. H., SOME EFFECTS OF SEWER EFFLUENT ON MARINE LIFE, California Fish and Game, Vol. 50, No. 1, 1964, pp. 33-41.

The author presents data on the detrimental effect of pollution from sewer-outfalls on certain marine fish and shellfish at a site on the California coast. Trauma in the form of lesions and tumors was very common.

*MARINE FISH, *SHELLFISH, *SEWER EFFLUENTS, *CALIFORNIA, *WATER POLLUTION EFFECTS, water pollution, animal pathology, animals, aquatic animals, aquatic life, fish, marine animals, saline water fish, wildlife, pathology, geographical regions, Pacific coast region, regions, southwest U. S., outlets

467. Zobell, Claude E., THE OCCURRENCE, EFFECTS, AND FATE OF OIL POLLUTING THE SEA, International Journal of Air and Water Pollution, Vol. 7, No. 2/3, May, 1963, pp. 173-198.

A general summary article on occurrence, sources, effects, and fate of oil polluting the marine environment, both naturally occurring and resulting from man's activities. Considers submarine seeps, land drainage, wrecked oil tankers, oil discharges from ships, and "natural" oily materials as sources. Principal geographic areas of occurrence are identified. The effects of oily wastes related to fire hazard, pollution of recreational beaches, sea birds, oysters, and other shellfish, finfish and other fauna, plantlife, bacterial population, oxygen regimen, and in fouling of boats and marine structures are presented. The roles of water movements, suspended solids, bottom and beaches, autoxidation, and bacteria in determining the "fate" of polluting oil are considered. This article also contains an extensive bibliography on physical, chemical, and biological effects of oil as a pollutant in the marine environment.

*WATER POLLUTION, *WATER POLLUTION EFFECTS, *SEA WATER, WATER POLLUTION SOURCES, *OILY WASTES, ships, oil wells, saline water, water types, oily water, wells, wastes, organic matter, oxygen sag, oxygen requirements, aquatic animals, aquatic life, animals, fish, wildlife, aquatic plants, bibliographies

468. THE ZUYDERZEE WORKS, Netherlands Government, Information Service, The Hague, Netherlands, 1967.

The technical progress of land reclamation from the Zuiderzee and construction of the Barrier Dam is described. Problems of salification, flushing, erosion, and treating soil are discussed. Pumping, dyke construction, and soil distribution are described.

*LAND RECLAMATION, *DAM CONSTRUCTION, *FOREIGN COUNTRIES, coastal engineering, erosion, shore protection, agricultural engineering, saline water intrusion, soil treatment, geographical regions, regions, construction, engineering

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